CHAPTER 12

12.1 GOVERNMENT PROGRAMS

There has been no revision of the National Program of Greece during 1997. Greece is one of the European countries possessing high wind energy potential. It is among the aims of the government to substitute expensive imported fuel, currently used for electricity production in a large part of the Greek territory, by exploiting the country's wind potential. Government support for wind energy exploitation is part of a larger new policy, concerning renewable energy sources. The major strategic goals of the national policy for the development of the renewable energy sources are:

1. Increase of the efficiency of the energy system
2. Environmental protection by decreasing the emission of atmospheric pollutants
3. Improvement of the safety of the energy system by diversifying energy supplies
4. CO_2 emissions by 2000 at the levels of 1990
5. Decentralization of energy production
6. Active involvement of the Greek industry - creation of new jobs
7. Development of new technology

In 1995, a target of 350 MW of installed wind energy capacity by the year 2005 was announced by the Ministry for Development (MD). In this year, a significant stimulus to the development of wind energy in Greece has been given by the introduction of a new legal framework. The new Law 2244/94, dealing with and regulating the electricity production from renewable energies, has been followed by a ministerial decree detailing its implementation. The main features of the new framework regarding wind energy are the opening of the market to the private sector and the precise definition of the tariffs for the energy produced. In addition, the Public Power Corporation of Greece (PPC) is obliged to buy the wind-produced electricity with contracts having a 10-year duration, with the possibility of a 10-year extension.

There are two national programs currently supporting wind energy projects. Wind projects may be subsidized up to 45% of the project cost and get up to 45% reduced interest rate soft loan. This is implemented within a continuous program according to the "Law for the Economical Development" 1892/90 of the Ministry for National Economy.

The so-called Operational Program for Energy (OPE)-Renewables within the 'Community Support Framework, for the years 1994 - 1999, is implemented by the Ministry for Development. The total budget for renewables including private contribution is 166.6 MECU and the maximum budget allocated for wind energy is 43.3 MECU representing 26% of the total budget. Financial support for wind energy is 40%, considering the maximum subsidized project cost 1,150 ECU/kW.

During 1997 there have been two calls for proposals in the framework of the OPE. After the first call, five proposals for wind projects were accepted, with a total budget 28.4 MECU, corresponding to 22.8 MW installed capacity. The results of the second call will be announced during 1998.

12.2 COMMERCIAL IMPLEMENTATION OF WIND ENERGY

The development of wind energy within the last eight years is shown in Figures 12.1 and 12.2, where the capacity

of installed wind turbines, the annual energy production, and the wind farm's capacity factor are illustrated. In the same period, the installed conventional capacity was increased from approximately 9 GW in 1990 to approximately 10 GW in 1997. It is clear that, in large part, the development of wind energy was between 1991 and 1993, when PPC put into operation its MW scale wind parks. The contribution of PPC to the total installed capacity is today as high as 88%. The rest of the capacity belongs to public companies and local authorities, while only a few hundred kW are owned by individuals.

Three WECS of total capacity of 1 MW have been connected to the electricity supply network in 1997, bringing the total installed wind energy capacity up to 28.6 MW (159 machines).

The wind turbines installed in Greece are constant speed, stall or pitch-regulated machines, constructed in Denmark, Belgium, and Germany. The only wind turbine of variable speed technology is a 150-kW, stall-regulated machine, which was designed and manufactured in Greece.

The energy produced from wind turbines during 1997 is approximately 38 GWh, while the energy produced in 1996 and 1995 was 37.2 GWh and 33.4 GWh respectively. Figure 12.2 shows the electricity produced from wind turbines for the last six years and the corresponding capacity factor. The last was calculated excluding the two PPC wind farms (10.2 MW in total), which have been out of operation since January 1994.

The two biggest wind farms of PPC, 5.1 MW each (17x300 kW Windmaster Wind turbine), have been out of operation since the beginning of 1994 due to serious damage on their rotor blades. The defect was detected during commissioning. The replacement of the blades began during 1997 and is expected to be completed in 1998 for both wind parks.

12.3 MANUFACTURING INDUSTRY

Except for a couple of small wind turbine manufacturers (typical range 1.0-5.0 kW),

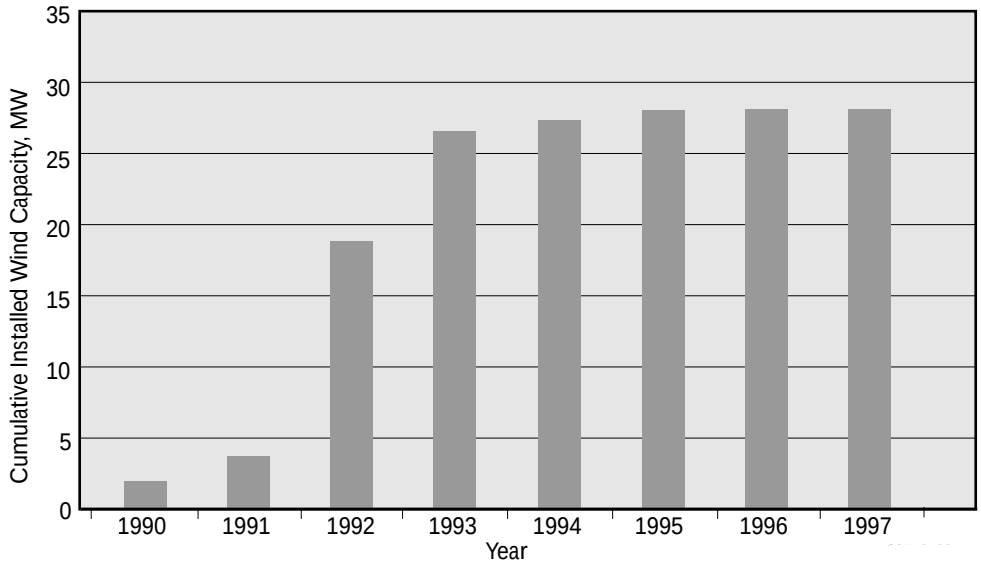

Figure 12.1 Installed wind capacity in MW.

Figure 12.3 This 1.5-MW wind farm on the island of Andros is owned by the Public Power Corporation of Greece.

there is no wind turbine manufacturing industry in Greece. However, all the tubular towers for imported machines of PPC were constructed in Greece by two private companies, following the original drawings. The steel industry is quite developed in the country and can easily support wind turbine manufacturing. In the past, the Hellenic Aerospace Industry (HAI), was involved with the construction of wind turbines for PPC. But its activities were limited to a program of 50 machines based on imported Danish know-how.

A certificate from a certifying authority is required to operate a wind turbine in Greece with rating of more than 20 kW, unless it is owned by PPC. The Center for Renewable Energy Sources (CRES) is, by law, the certifying authority for wind turbines in Greece. However, CRES accepts approval certificates issued by authorized institutions, while it is working on certification procedures and standards to be followed nation-wide, taking into account the individual climate characteristics of Greece.

12.4 ECONOMICS

The system of power generation in Greece is divided into two categories: the so-called interconnected system of the mainland and the autonomous power plants of the islands. PPC is the only utility responsible for production, distribution, and exploitation of electricity. Despite the different production costs in the two systems, a single price for electricity is charged all over the country, depending on the identity of the consumer and the voltage class. During 1997, there has been an increase of 3.5% for all PPC tariffs. The following tariffs for the three voltages are the most typical.

1. Low Voltage 25.83 Drs / kWh
2. Medium Voltage 21.69 Drs / kWh and 965 Drs / kW (peak power value)
3. High Voltage 13.64 / 7.00 / 9.46 Drs / kWh, peak / min load / rest hours respectively 2191 Drs / kW (peak power value)

The prices paid by PPC for renewable energies are based on the actual selling price. For the autonomous island grids the prices are set at 90% of the low voltage tariff, i.e. 23.24 Drs/kWh. For the interconnected grid, the tariffs have two components: energy and power (capacity credit). The energy component is set at 90% of the medium or high voltage tariffs, depending on the type of grid connection of the wind power plant. The power component is set at 50% of the respective PPC power charge.

1. Medium voltage 18.79 Drs/kWh and 241.2 drs/kW x P (P: the maximum measured power production over the billing period)
2. High voltage 12.27/ 6.30/ 8.52 Drs/kWh, peak/min load/rest hours respectively 547.8 drs/kW x P (P: the maximum measured power production between two successive measurements in the peak hour zone)

The total cost of wind power projects depends on the type of wind turbine, the size and accessibility. It varies between 330,000-400,000 Drs/kW. The generated wind power cost could be assumed to be between 9.0 and 16.0 Drs/kWh, depending on the site and project cost.

The typical interest rate for financing any project without subsidies is about 16%. However, many investments including wind projects may profit by reduced soft loan according to the so called "Law for the Economical Development" 1892/90.

12.5 MARKET DEVELOPMENT

Low selling prices in conjunction with the restriction of power generation from the private sector (with the exception of auto production), strongly affected wind energy development, although the first wind turbines have been operating since 1984. As a result, wind energy was limited to the activities of PPC and of some public organizations.

As soon as the new Law 2244/94 was issued in early 1995, a great interest has been shown by the private sector in developing wind power projects. According to the Law, anyone can develop power plants up to 50 MW from renewable energy and sell electricity to PPC, marking the end of the monopoly of PPC on power generation from wind energy. Other features affecting the development are more simplified procedures (less bureaucracy) and attractive buy-back prices. Until now, applications for a total of 1,000 MW have been submitted to the Ministry of Development from which approximately 800 MW are for wind energy projects. During 1997, eight wind energy projects of a total 40-MW capacity have completed the licensing procedure and an installation license has been issued. These projects are to be implemented in 1998.

The first large wind energy project under the new legal framework (10 MW on the island of Crete) is under construction. It is expected to be operational by summer 1998.

Environmental impacts such as visual impact and noise emissions are minimal due to the landscape characteristics of Greece. Almost all wind power plants are sited in remote areas, thus minimizing complaints. In addition, no bird kills have been reported.

Although strong opposition defeated a projected wind farm on Lesvos Island (due to archaeological interest in the area), there has been no other significant opposition against wind energy to date. The public attitude is rather positive in general. However, special attention should be given when planning projects on small tourist islands with strictly traditional architecture.

12.6 GOVERNMENT-SPONSORED R, D & D PROGRAMS

The Ministry of Development promotes all R, D&D activities in the country. Government-sponsored R, D&D activities include applied and basic R&D as well as demonstration projects.

Key areas of R&D in the field of wind energy in the country are: wind assessment and integration; standards and certification; development of wind turbines; aerodynamics, structural loads, blade testing, noise, power quality, wind-powered desalination and integration in autonomous power systems. There is no activity in Greece concerning MW-size wind turbines or offshore deployment.

12.6.1 Research and Development

A project for the development of a 450-kW wind turbine was initiated within the framework of the EPET-II National Program in 1995. The contract of 1.9 MECU was signed the summer of 1995 between a consortium of companies and the General Secretariat for Research and Technology (GSRT). The project is aimed at both the development of a 450-kW variable-speed, stall-regulated wind turbine, and the development of blade manufacturing technology. The contract has a duration of three years and the prototype is expected to be installed at the test site for extensive measurements in 1998.

CRES is the national organization for the promotion of renewable energy in Greece and, by law, the certifying authority for wind turbines. CRES is mainly involved in applied R&D and is active in the field of aerodynamics, structural loads, noise, power quality, variable speed, wind-desalination, standards and certification, wind assessment, and integration.

The development of a national certification system for wind turbines is considered a crucial parameter for the successful implementation of new strategic plans for extensive use of wind energy in the country. CRES' Wind Energy Department is continuing the development of the National Certification System, as well as

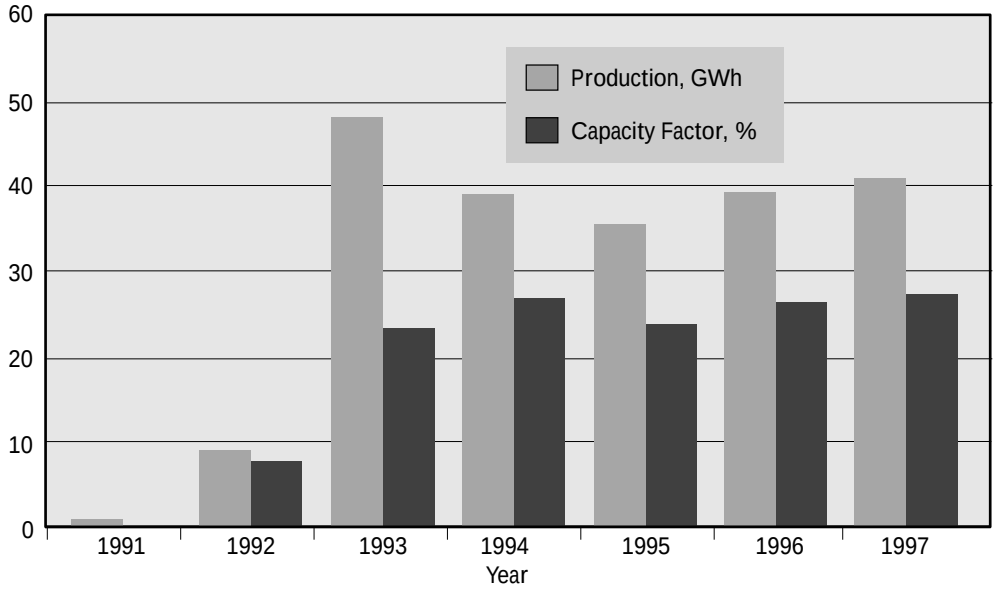

Figure 12.2 Wind power annual output and capacity factor.

participating in the standardization work carried out by the Hellenic Organization for Standardization (ELOT) in the framework of European and International organizations, regarding wind energy matters.

Greece has been actively involved in the IEC TC-88 since 1/1/1997 and participates in WG 9 dealing with the development of a standard for Wind turbine Certification, WG 10 dealing with power quality and WG 11 dealing with Wind turbine load measurement. Furthermore, Greece is actively involved in the European standardization work participating in the activities of CLC/BTTF83-2 and its wind generators.

The CRES blade testing facility is going to be used as an integral part of the certification system underway. The facility is fully operational and several blade tests have already been conducted. The blade testing facility, which is one of the most advanced testing facilities in the world, can be used for static, dynamic or fatigue testing of blades up to 25-m long.

The CRES Wind-Diesel Hybrid laboratory system, which simulates small autonomous grid operation common in the islands of the Aegean Sea, has been fully operational and several tests have been made. The system can be effectively used in optimizing the integration of renewable energies in such systems.

A number of research projects were running or initiated at CRES during 1997, cofunded by DGXII and GSRT (the Greek Secretariat for Research and Technology) aiming at:

1. Characterizing the main features of complex or mountainous sites, as most of the favorable for wind energy development sites are of such topography; and identifying the crucial parameters affecting both the power performance and the loading of different types of wind turbines operating at such environments. In that direction, new techniques are under development for power-curve measurement of wind turbines operating in complex terrain.
2. Developing new techniques for power quality measurement and assessment.
3. Contributing know-how to wind turbine standardization procedures.
4. Developing blade testing techniques within the in-house experimental facility.
5. Understanding generic aerodynamic performance of wind turbine blades through CFD (Computational Fluid Dynamics) techniques.
6. Developing cost-effective micro-siting techniques for complex terrain topographies.
7. Developing GIS (Geographic Information System) techniques for optimum wind-energy planning on a local level.

Basic R&D on wind energy is mainly performed at the country's technical universities. The Fluids Section of the Mechanical Engineering Department of the National Technical University of Athens (NTUA) is active in the field of wind modeling, rotor aerodynamics, load calculation, fatigue analysis noise and wind farm design.

In 1995, the R&D activities at the Fluids Section of NTUA, have focused on: a) refining design tools, siting predictions and noise level estimations, b) stall and its control by means of air jets and mechanical vortex generators. More specifically, R&D focuses on the following.

1. Siting: Further development of the existing numerical tools, has produced a model based on a telescopic local grid refinement which increase the accuracy of calculations

significantly (Grid spacing of 20 m is now achievable).

2. Aerodynamics: a) A new viscous-in viscid interaction model for the unsteady flow around profiles has been concluded and validated, b) A comparative investigation of different turbulence models has been initiated and is aiming at the best possible prediction of stall, c) The boundary layer control on a systematic numerical investigation based on CDF tools was started by means of vortex generators of the air jets or mechanical type. d) The GAST aeroelastic tool was given a user friendly form and is currently disseminated, e) 3D Navier-Stokes models for rotor aerodynamics have started being evaluated.
3. Aeracoustics: A model for predicting noise emissions from wind parks and their propagation has been concluded, and is now being evaluated against measurements.

The Applied Mechanics Section of the Mechanical and Aerospace Engineering Department of the University of Patras (UP) has, since1990, focused on educational and R&D activities involving composite materials and structures. Emphasis has been placed on structural design and dynamics of composite rotor blades of wind turbines. Experience has been acquired as a result of involvement in research projects supported either by the GSRT and/or the European Union.

The University of Patras has successfully completed structural designs for a 5.5-m and a 10-m GRP blade, the verification of which was performed by full scale static and modal tests at the CRES blade testing laboratory. During 1997, in the framework of the EPET-II National Program, a 14-m GRP rotor blade was designed by UP and is currently under construction by a Greek industrial partner. In collaboration with CRES, a comprehensive analytical and experimental program was initiated as to the effects of structural damping on blade fatigue design and performance.

Other research activities of the Applied Mechanics Section, both analytical and experimental, have mainly focused on (a) fatigue failure prediction of multidirectional laminates under combined stress state and variable amplitude loading, (b) probabilistic design of composite-made structures (c) non-destructive testing of composite materials using acoustic emission coupled with pattern recognition techniques for signal analysis.

The Electrical Engineering Department of NTUA has been actively involved in the field of wind energy since the beginning of the 1980s, participating in R&D projects sponsored by the EU and other institutions and co-operating with universities and research centers from many European countries. In 1997, the Power Section of the Department of Electrical and Computer Engineering continued research activity in the integration of renewable energies in the electric grids and the design of the electric part of wind turbines. In collaboration with CRES, an extension of the developed methodologies for GIS-assisted optimal site selection and integration to the grid has been made and applied. Moreover, a systematic procedure, consisting of the application of three computer programs has been developed for the Public Power Corporation (PPC) of Greece, in order to estimate the impact of a high wind energy penetration on the islands and the consequent penetration limits.

The Electrical Engineering Department of NTUA is also involved in the design of the electrical components of wind turbines. Electric machinery, power converters, and control systems for variable speed wind turbines are studied and small simulators are developed in the Electric Machines laboratory. In this

framework, the design of a 5-kW generator with permanent magnets has been made and tested and a new one for 20 kW is under development.

12.6.2 Demonstrations

The main demonstration programs in wind energy currently under way in Greece are financed within the framework of the Thermie program of the EU. The following three demonstration projects of PPC were on-going in 1997.

1. Three wind turbines in Moni Toplou, Crete: Two Tacke 500-kW wind turbines were commissioned in December 1993 and produced 10510 MWh during their four years of operation. The third wind turbine is a Nordtank 500 kW, commissioned in April 1995. It has produced 4238 MWh until the end of 1997. More specifically, during 1997, the two Tacke wind turbines have produced 2620MWh while the Nordank had a total energy production of 1617 MWh.
2. Wind-diesel system in Astypalea: A 500-kW V-39 Vestas pitch-regulated wind turbine and a new 500-kW diesel generator will be installed in Astypalea in 1998. The project was delayed due to siting problems, which were resolved during 1997. The aim of the project is to maximize the penetration of wind energy through a load management system based on setting the power limit of the wind turbine. At the end of 1997, the installation license has been issued by the Ministry for Development.
3. Large advanced autonomous wind / diesel / battery power supply system in Kythnos: The aim of this project is the demonstration of the technical feasibility of the integration of very high penetration of wind energy production in large supply systems. This large modular system for the island of Kythnos is designed for the combination of diesel generator sets, battery storage, rotating phase shifter, five small wind energy converters and one additional large wind energy converter. This large wind energy converter with a power output of 500 kW will supply a great portion of the power demand. It will be the first time that a portion of more than 50% of the energy demand is realized by wind turbines and, due to this, the diesel generators can be totally stopped when the power output of the wind turbines is sufficient. Furthermore, the already existing PV system with a nominal power of 100 kW as well as the existing 5 energy converters of type Aeroman (with 33 kW rated capacity each) will be integrated into the wind / diesel / battery system. The project will be carried out from PPC and SMA. The project is close to getting the installation license and construction work is expected to start in 1998.

In the framework of the Thermie program, another demonstration project was ongoing on the Greek island of Mytilini by the local municipality in collaboration with a Greek private enterprise.

4. The 2.5 MW wind farm on the island Mytilini: The project concerns the installation of a 2.5 MW wind farm on the island Mytilini located in the Aegean Sea. The wind farm will consist of five 500-kW variable-speed, pitch-regulated wind turbines manufactured by Enercon. The power performance of the wind farm will be monitored and evaluated in relation to local grid penetration capability. Measurements of the wind potential in the area have been conducted during 1997. The project is close to getting the installation license and

construction work is expected to start in 1998.

In the framework of the APAS project, an autonomous wind-desalination project has been developed on the Greek island of Therasia.

5. Autonomous Wind-Desalination system on the island of Therasia: The project concerns the installation of an autonomous wind-powered small desalination system in Therasia. Therasia is a small island in the Aegean Sea very close to the island of Santorini. The desalination system is based on reverse osmosis technology with a nominal water production capacity 5m3 per day. The wind turbine has a rated power of 15 kW, manufactured by Vergnet SA. The purpose of the project was to demonstrate the feasibility of developing off-grid, autonomous wind desalination units in remote areas. The commissioning of the system was in July 1997.

In the framework of the Greek Operational Program of Energy, CRES is planning the installation of a 2.5MW wind farm:

6. CRES 2.5MW Wind Farm in complex terrain: The wind farm will comprise five different types of wind turbines with rated capacity of 500 kW each. The purpose of the project is to study the effects of the complex topography in the performance of the wind turbines as well as of the overall wind farm.

Finally, an old Thermie project is ongoing on the Greek island of Mykonos:

7. A 300-kW induction wind turbine connected to the desalination plant of Mykonos Island: The project was originally planned for the Island of Ithaki and was transferred to the island of Mykonos due to difficulties of implementation. The aim is to couple a medium-sized wind turbine with a desalination plant with the opportunity to operate as a standard grid-connected machine, if necessary. During 1997, wind measurements at two potential sites have been accomplished in order to finalize the site where one wind turbine of 300-kW rated capacity manufactured by Nordtank will be installed.

CHAPTER 13

13.1 GOVERNMENT PROGRAMS

13.1.1 Aims and Objectives

Since Italy's energy supplies depend heavily on imported fossil fuels, the government has always been in favor of developing domestically available sources, with special emphasis on the renewable ones, for diversification and security reasons and to relieve the balance of trade. In the electricity sector, hydroelectric and (albeit to a much less extent) geothermal power plants have long played a noteworthy part in meeting the demand.

In the last few decades, however, the continuing growth of electricity consumption, in conjunction with increasing difficulty in finding new hydro-power sites and geothermal resources, has gradually reduced the electric energy share from these renewable sources, which is currently around 20% of the total.

Over the past decade, the government has therefore also taken an interest in developing new renewable sources such as wind energy, solar energy and biomass

13.1.2 Strategy and Targets

This interest was clearly stated in the National Energy Plan (PEN) issued in August 1988. In particular, as far as wind energy was concerned, the1988 PEN set a target of 300-MW capacity to be installed by 2000. This target might be raised to 600 MW if large megawatt-sized machines have become commercially available in the meantime.

In accordance with this policy, the government took measures aimed at encouraging the development of new renewable sources through the Ministry of Industry, Commerce and Trade (MICA). As for wind energy, however, MICA has not implemented a specific research, development and demonstration (R,D&D) program on its own, but has co-ordinated the programs of a few state-owned organizations, mainly the research agency ENEA (the Italian National Agency for New Technology, Energy, and the Environment) and the electricity utility company ENEL (formerly the Italian National Electricity Board).

ENEA has, among other things, supported the wind energy industry by providing a number of Italian wind turbine projects with technical and financial assistance and, more recently, by undertaking additional actions including, for instance, public information and setting-up of a national wind turbine certification system.

ENEL, in accordance with its former role as a state Board, has tested a number of Italian and foreign-made wind turbines at its own facilities and launched the construction of two demonstration wind farms with Italian-made machines. A cooperation agreement was signed by ENEA and ENEL in 1987.

More recently, however, ENEL's position has changed following its setting-up as a joint-stock company (in Italy, Società per Azioni). Although the sale of the company's shares to the public is still awaited, this change has brought about a new, more market-oriented attitude of ENEL also towards renewables. As for the wind sector, this means that, for the future, the ENEL Group (including ENEL and some subsidiary companies) is now mainly considering the undertaking of commercial ventures. In 1997, however, ENEL (and especially its R&D Department) has still worked on completion of the activities launched under its former programs. To be consistent with previous IEA Reports, an update on these ENEL activities is still

provided in the 1997 Report in Section 6 "Government-Sponsored R,D&D Programs".

Going back to the government's earlier measures for encouraging commercial wind energy applications, mention should first be made of Laws No. 9 and 10, passed by the Parliament in January 1991. Although these Laws were major steps forward, in that they created the basic conditions for privately-owned wind farms to be developed and clearly stated some fundamental principles, it should be recognized that their actual financial support to wind plant installations has been very poor.

Much more effective has proved to be the subsequent initiative of the Interministerial Committee for Prices (CIP), which on April 29, 1992, issued Directive No. 6, which provided for premium purchase prices to be paid for the electricity produced from renewable sources or from other sources recognized as "assimilated" (e.g. thermal co-generation plants) and fed into the public grid.

These incentives raised a striking surge of interest towards wind farm development among private investors. As of June 30, 1995, private wind farm projects for a total capacity of about 720 MW had already been accepted by MICA into a list of plants admitted to compatibility checks with the ENEL system and (if built) also entitled to the special energy prices granted by CIP Directive No. 6/92. Additional projects totaling about 1500 MW were subsequently submitted in 1995 and 1996.

In the same time, however, some setbacks arose. To comply with the European Union's Directives and the government's ensuing Decree of July 15, 1996 concerning transparency of electricity tariffs, MICA issued the Decree of July 15, 1996, which established that, concerning new plants fed by renewable and assimilated sources and whose contracts had not yet been signed with ENEL, the incentive part of energy purchase prices should be paid only as far as financial resources were actually available at the "Cassa Conguaglio Settore Elettrico" (the body that manages financial resources devoted to implementing CIP 6/92).

This Decree gave rise to widespread concerns among wind energy developers, who saw it as a serious threat to the actual possibility for them to get profit from their plants. The matter was then settled only partly by a further Decree issued by MICA on February 24, 1997. This Decree allowed for full CIP 6/92 purchase prices to be paid to wind plants already on stream or under construction at that date or, in any case, included in the aforementioned list of June 30, 1995, thus bringing some relief to investors. As to projects submitted at a later date, the question was left open.

The debate has gone on through the whole year of 1997. Investors look forward to a new incentive provision like CIP 6/92, but purposely devised for really renewable sources only, thus leaving out the so-called assimilated sources (such as co-generation), which should be dealt with separately. Indeed, it is widely felt that mixing renewable and assimilated sources under the same provision has been the weakest point of CIP 6/92, which has turned to the detriment of the wind and other newborn sectors.

The government, for its part, in accordance with its commitment to reducing greenhouse and polluting emissions, also as a consequence of the Kyoto protocol, has been discussing, in late 1997, a program on "The Promotion and Development of Renewable Sources" setting the goal of getting 6.4 Mtep/year from new renewable sources by 2010. The ensuing wind capacity target would be 3,200 MW by 2010. ENEA is strongly

involved in supporting this program, particularly in taking care of the technical aspects. Considering all this, new wind market stimulation measures can also be expected shortly.

Along with the central government's policy, mention should also be made of the measures taken, in late 1996 and 1997, by the governments of some regions where wind resources are more plentiful (Apulia, Campania, Sicily). Within the framework of Regional Plans named POP (Piani Operativi Plurifondo) and with the help of funds granted by the European Union (e.g. the Structural Funds), these regions have made available capital cost subsidies that can cover a substantial part of the cost of a wind farm project (even up to a maximum of 70% in Sicily). The availability of POP funding can somehow make up for the lack of CIP 6/92 energy prices, or, if the latter are available, enhance considerably the profitability of a given scheme.

13.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

13.2.1 Installed Wind Capacity

In the year 1997, additional wind plants with a total rated capacity of 28.5 MW have been installed, bringing the total wind power in Italy to nearly 99 MW (see Figure 13.1 and Table 13.1).

Almost all of these plants have been installed in mountainous areas in the Apennines. A few are in Sardinia.

The largest of these plants, with a power of 21.6 MW, has been set up by the private developer IVPC (Italian Vento Power Corporation) at Sant'Agata di Puglia (in the Apulia Region in Southern Italy), thus

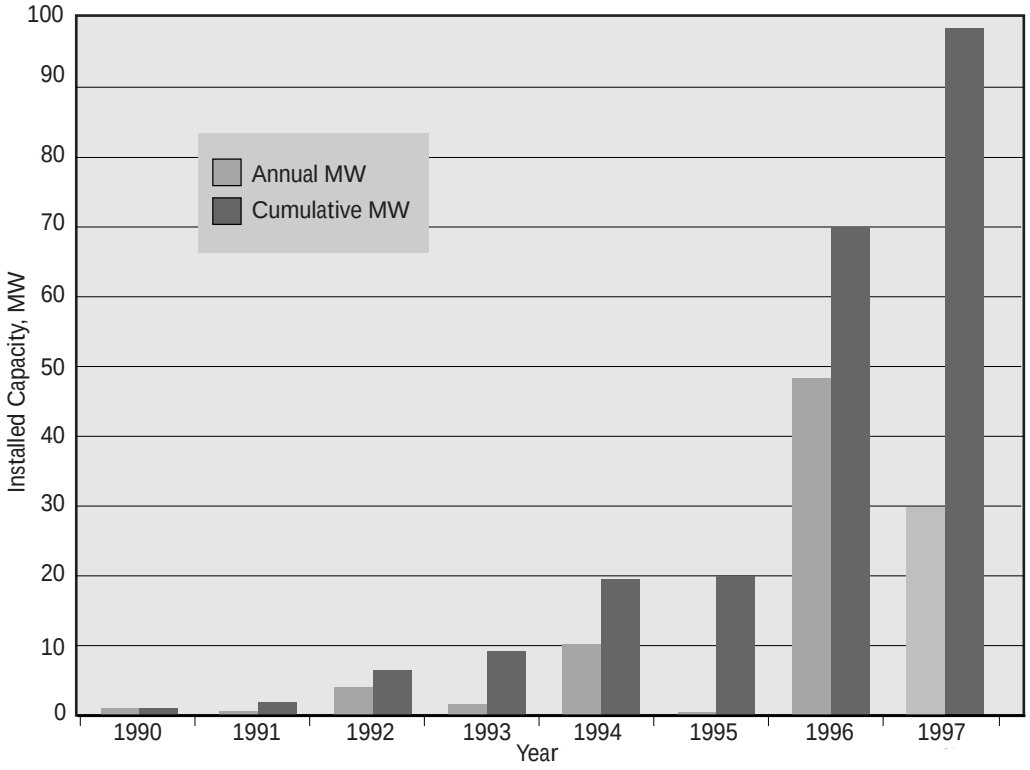

Figure 13.1 Trend of Italy's installed wind capacity in recent years.

bringing the total power at this site to 25.2 MW (3.6 MW was installed in 1996). It should be mentioned that, less than 10 km from this wind farm, another plant totalling 24 MW was built by the same IVPC company near the villages of Monteleone di Puglia and Anzano in 1996. A total of 82 wind turbines (of the 600-kW-rated V-42 model manufactured by Vestas), for a total capacity of 49.2 MW, are thus operating in the same area.

There were more new wind installations in 1996 as compared to 1997, but, according to the investors, the rate should improve again during 1998.

In any case, as compared to Italy's generating capacity (totalling about 66 GW, of which 54 GW belong to ENEL alone), the wind power penetration percentage still remains very small.

13.2.2 Plant Type

In all, 56 new wind turbines were installed in Italy in 1997, of which 38 were made by Vestas (Denmark) and 18 manufactured by WEST (Italy). The WEST model used is Lambda, rated at 320 kW, and the Danish one is Vestas V-42 of 600 kW. (See figures 13.2 and 13.3)

The total number of turbines in Italy is now 250, with an average rated capacity of 410 kW. The average power of turbines installed in 1997 rose to 510 kW.

Thirty-six Vestas V-42 wind turbines have been added to a wind farm near Sant'Agata di Puglia. The owner is the private investor IVPC. The remaining two V-42 units have been set up at Miscano (Campania) by Sanseverino, a private developer who is planning to set up 18 more machines in 1998. (See Figure 13.4)

Fourteen Lambda turbines are located in Sardinia as part of the Monte Arci wind farm, which is being built for the utility ENEL and will be completed in the Spring of 1998. The remaining four WEST turbines have been set up at two sites, namely two units at Bisaccia (Campania) by Alenia REI, and two units at Lamezia

Figure 13.2 Some of the 28 Vestas V-42 600-kW machines set up by IVPC near Monteleone di Puglia (Apulia Region, Southern Italy).

Figure 13.3 Another view of the 16.8-MW IVPC wind farm near Monteleone di Puglia. This plant and the neighboring wind farm of Anzano di Puglia make up a 24-MW cluster.

Terme (Calabria) by a local Consorzio Industriale (Industrial Consortium).

13.2.3 Performance

The technical performance has been fairly good, with an average availability of the latest wind farms ranging between 95-98%. Also the capacity factor for plants installed in the last two years has been around 0.3.

During 1997, the total wind energy output to the electrical system has been more than 150 GWh. This result has mainly been due to the good performance of the more recent wind farms erected in the Apennines range. In particular, the IVPC company reports an overall production of about 120 GWh from its wind farms, which have reached nearly 60 MW capacity in late 1997 (see Table 13.1).

With reference to operation of commercial plants, no incidents or accidents have been declared by their owners.

13.3 MANUFACTURING INDUSTRY

13.3.1 Manufacturers

Riva Calzoni and WEST are the Italian companies involved in the manufacturing of turbines. In particular, Riva Calzoni is devoted to the production and installation of the monoblade (single-bladed) machine M30-S2 of 350 kW. WEST is engaged in the field of both medium- and large-sized wind turbines.

Riva Calzoni

Since 1997 all activities concerning the production of wind turbines have been transferred to a new company, Riva Wind Turbines. The machines are assembled at a new factory in Foggia, where nine people are now working.

Eighteen turbines of the M30-S2 model were ordered in 1997 and will be erected in two wind farms in the first months of 1998. According to the company, around 40 units should be sold in 1998 and the possible production in the next few years would be 50-60 turbines / year.

Riva Calzoni is also present on the Italian market as a wind developer through another, newly-established company, Riva Wind Power.

WEST

The main activities carried out in 1997 by WEST have been the completion of refitting and re-commissioning of the 1.5-MW, 60-m-diameter GAMMA 60 prototype tested at Alta Nurra; the production of blades for a foreign manufacturer; and the replacement of hubs of its 320-kW Medit machines with other, teetering ones. The machine that has resulted from these modifications has now been named Lambda. By April 1998, all the WEST Medit medium-sized turbines installed will be turned into Lambda, characterized by a teetering hub, two blades, and a power of 320 kW.

In addition, WEST has also manufactured two units of the pre-series version of the GAMMA machine, the GAMMA 2000, still 60 m in diameter, but rated at 2 MW. The blades of one of these units were also manufactured in the WEST workshop.

WEST has so far been operating as a prospective wind farm developer. In past years, the company submitted a number of projects, which have been admitted to the list of plants entitled to CIP 6/92 energy purchase prices (see above).

13.3.2 Support and Component Industries

Some Italian and foreign component industries and consultants have been supporting wind developments in Italy. The most important among these are the following.

Garrad, Hassan & Partners (consultant);

Flender (gearboxes);

Atout Vent (blades);

Figure 13.4 Partial view of the IVPC wind farm near Anzano di Puglia, with 12 Vestas V-42 600-kW machines totaling 7.2 MW.

Elettroadda, Magrini Galileo (electrical components);

Monsud, Siderpali (towers).

13.3.3 New Developers

In addition to wind farm developers already mentioned in this or previous reports (such as IVPC, Riva Wind Power, WEST, Sanseverino, etc.), mention should also be made of the ENEL Group. In accordance with its new, more market-oriented policy in the wind energy field, ENEL has now conferred upon the subsidiary company ISMES all activities aimed at building commercial wind power plants. In 1997, ISMES has signed an agreement with Riva Calzoni by which ISMES has joined in three wind energy ventures launched by Riva to build wind farms totaling as much as 22.4 MW in Southern Italy in the period 1997-1999.

13.4 ECONOMICS

In this report, currency conversion has been made assuming 1 USD = 1750 ITL.

The utility ENEL sells electric energy to final consumers at prices that can vary over quite a wide range depending on technical factors, such as the contracted power and the energy consumption, and also (for domestic consumers) on other, social factors (e.g. whether or not a family resides permanently in a given house).

Roughly speaking, as of January 1997, the selling price to typical domestic consumers ranged from ITL 100 to ITL 300/kWh (USD 0.06 to 0.17/kWh). At the same date, the selling price to industrial consumers ranged from ITL 90 to ITL 180 / kWh (USD 0.05 to 0.10/kWh). These are all net prices without taxes.

As noted above, CIP Directive No. 6 of April 29, 1992 has allowed special buying prices for wind-generated electricity fed by autonomous producers into the ENEL system. The 1997 rates have been fixed at:

ITL 195.6/kWh (USD 0.111/kWh) for the first eight years of plant operation (on condition that the plant makes available its whole capacity or a fixed share of it);

ITL 98.3/kWh (USD 0.056/kWh) for the remaining lifetime.

The latter rate is intended to pay the producer for the cost ENEL would bear in generating the same amount of energy, while the extra-amount (i.e. ITL 97.3/kWh, around USD 0.055/kWh) allowed for the first eight years is intended to help bear the extra cost of setting up wind energy plants rather than conventional plants.

According to CIP 6/92, in case of subsidies to capital cost, the extra-amount is to be reduced, in 1997, by ITL 37.8/kWh, thus bringing the overall price down to 157.8 ITL/kWh (about USD 0.090/kWh).

It should be recalled as noted above that the CIP 6/92 prices are now actually available only for plants that were already operating or under construction in early 1997 or for those projects had been included in the MICA lists before June 30, 1995.

As for costs of commercial plants, the ex-factory cost of the Italian-made Riva Calzoni machine M30-S2 of 350 kW is about ITL 480 million (about USD 275,000).

The total project costs are strongly dependent on the size of wind farms and the characteristics of sites and grids. In Italy, the costs given by investors for the latest wind farm projects are in the range of ITL 1.8 - 2.2 million/kW (about USD 1,000 - 1,300/kW). It should always be borne in mind, that most Italian sites are located in mountainous terrains.

No general, reliable information can as yet be given on typical rates of interest applied to the financing of wind power plants. It can however be stated that

Table 13.1 Wind Turbine Generators Installed in Italy (as of 31 December 1997).

SITE	OPERATOR	GRID CONNECTION	NO.	WTG TYPE	WTG POWER (kW)	ROTOR DIAMETER (m)	TOWER HEIGHT (m)	PLANT POWER (MW)
Alta Nurra	ENEL S.p.A.	Jul. 94	1	M30 S-1	250	33	33	0.25
		Apr. 92	1	MEDIT I	320	33	26	0.32
		Mar. 91	1	MS-3	300	33	25	0.30
		Apr. 91	1	WD34	400	34	32	0.40
		May 92	1	GAMMA 60	1500	60	66	1.50
Bisaccia	Regione Campania	Jan. 92	4	Lambda	320	33	26	1.28
		Apr. 93	2	MEDIT I	320	33	26	0.64
		Jan. 92	3	AIT-03	30	10	12	0.09
		Apr. 93	13	AIT-03	30	10	12	0.39
Palena (Sangro)	Consorzio Bonifica del Sangro	Feb. 94	3	MEDIT I	320	33	26	0.96
		Feb. 94	1	VESTAS V27	220	27	31	0.22
		Feb. 94	1	VESTAS V20	100	20	24	0.10
Villagrande	Comune	Apr. 93	2	MEDIT I	320	33	26	0.64
Acqua Spruzza (Frosolone)	ENEL S.p.A.	Winter 94	2	M30	200	33	33	0.40
		Winter 94	2	MEDIT I	320	33	26	0.64
		Winter 94	2	MS-3	300	33	25	0.60
		Winter 94	2	WD34	400	34	32	0.80
Frosolone	Comunità Montana Sannio	1994	1	MEDIT I	320	33	26	0.32

Table 13.1 Wind Turbine Generators Installed in Italy (as of 31 December 1997) (continued).

SITE	OPERATOR	GRID CONNECTION	NO.	WTG TYPE	WTG POWER (kW)	ROTOR DIAMETER (m)	TOWER HEIGHT (m)	PLANT POWER (MW)
Oristano	Consorzio Industriale	May 92	1	MEDIT I	320	33	26	0.32
Carloforte	N.A.	June 94	3	Lambda	320	33	26	0.96
Monte Uccari (Nurra)	Consorzio Bonifica di Nurra	End 94	5	Lambda	320	33	26	1.60
San Simone (Nurra)	Consorzio Bonifica Sardegna	Jan. 93	1	M30	200	33	33	0.20
Brunestica (Nurra)	Consorzio Bonifica di Nurra	1994	3	MEDIT I	320	33	26	0.96
Tocco da Casauria	Comune	June 92	2	M30	200	33	33	0.40
Campanedda	Consorzio Bonifica di Nurra	1994	4	M30 A	250	33	33	1.00
Ottava	Consorzio Bonifica di Nurra	1994	4	M30 A	250	33	33	1.00
Villacidro (CA)	Consorzio Industriale	N.A.	4	HMZ Windmaster	150	21.8	23	0.60
		Spring 87	2	HMZ Windmaster	160	21.8	23	0.32

Table 13.1 Wind Turbine Generators Installed in Italy (as of 31 December 1997) (continued).

SITE	OPERATOR	GRID CONNECTION	NO.	WTG TYPE	WTG POWER (kW)	ROTOR DIAMETER (m)	TOWER HEIGHT (m)	PLANT POWER (MW)
Villa Favorita	Società Villa Favorita	N.A.	1	HMZ Windmaster	150	21.8	23	0.15
Frontone (PS)	ANAS	N.A.	1	Leroy Sonas LS PL 315	216	N.A.	N.A.	0.216
Collarmele (AQ)	Marsica Gas	July 93	1	Riva M30 A	250	33	33	0.250
Ostuni (BR)	Massari V.	Apr. 92	1	HMZ	150	21.8	23	0.150
Assemili (CA)	CO2 Industriale	Oct. 92	1	VESTAS 227	225	27	31	0.225
Casone Romano (FG)	Local	Dec. 94	9 1	M30A M30-S2	250	33	33	2.6
Mazara del Vallo (TP)	Sicil Marin	Aug. 95	1	Floda 600 (Markhams)	600	36	42	0.6
Montefalcone (BN)	IVPC	Apr. 96	12	Vestas V42	600	42	40	7.2
Alberona (FG)	IVPC	Apr. 96	5	Vestas V42	600	42	40	3
S. Agata di Puglia	IVPC	Oct. 97	42	Vestas V42	600	42	40	25.2
Monteleone di Puglia	IVPC	Dec. 96	28	Vestas V42	600	42	40	16.8

Table 13.1 Wind Turbine Generators Installed in Italy (as of 31 December 1997) (continued).

SITE	OPERATOR	GRID CONNECTION	NO.	WTG TYPE	WTG POWER (kW)	ROTOR DIAMETER (m)	TOWER HEIGHT (m)	PLANT POWER (MW)
Anzano di Puglia	IVPC	Dec. 96	12	Vestas V42	600	42	40	7.2
Collarmele (AQ)	Marsica Gas	Sep. 96	6	M30A	250	33	33	1.5
Collarmele (AQ)*	ENEL	Jan. 97	35	M30-A	250	33	33	8.75
			1	M30-S2	350	33	33	0.35
Lamenzia T. (CZ)	Consorzio Industriale	1997	2	MEDIT I	320	33	26	0.64
Monte Arci (OR)	ENEL	Dec. 97	14	Lambda	320	33	26	4.48
Castelfranco in Miscano (BN)	Sanseverino	Aug. 97	2	Vestas V42	600	42	40	1.2
						TOTAL		98.78

some Italian banks are now taking into consideration the financing of wind projects as a part of their business.

13.5 MARKET DEVELOPMENT

13.5.1 Market Stimulation Instruments

As stated earlier, the electricity produced from renewable sources and fed into ENEL's network has been entitled to premium purchase prices, to be periodically updated, by Directive No. 6/92 issued by CIP (Interministerial Committee for Prices). The 1997 rates are ITL 195.6/kWh for the first eight years of plant operation and ITL 98.3/kWh for the remaining lifetime.

These purchase prices have now actually been restricted to a number of plants, already existing or planned, for a total of about 720 MW following the government's Decrees of July 19, 1996 and February 24, 1997.

A new legislative measure is foreseen to be issued in 1998 in order to define a more up-to-date form of energy purchase price incentives than those of CIP No. 6/92. According to people involved in renewable energy development, a new provision should take into account the following criteria.

1. Incentives should be given to energy production for the whole plant lifetime;
2. Really renewable sources should be dealt with separately from the "assimilated" ones like e.g. co-generation;
3. Proposals should preferably be selected on the basis of a competition among energy purchase prices offered by private investors;
4. The total yearly amount of incentives should be predetermined;
5. Initiatives accepted but not realized after a fixed period should be canceled;
6. Careful, continuous monitoring should be carried out in order to verify and possibly modify the shares of financing amongst the different technologies.

As discussed in the 1996 IEA Wind Energy Annual Report, the governments of some regions of Italy have made available capital cost subsidies that can cover a substantial part of the cost of wind farm projects within the framework of their Regional Plans named POP (Piani Operativi Plurifondo). The Campania and Apulia Regions, in particular, have granted support to 20 wind farm projects; the sum granted till now is about ITL 70 billion (USD 40 million).

In addition, for 1997, a program was announced by the Region of Sicily concerning the increase of energy production through renewable sources such as solar, wind and geothermal energy. A total amount of ITL 52 billion (USD 30 million), utilizing also the European Union's Structural Funds, has been allocated in order to support investors with a contribution to capital cost up to 70%.

13.5.2 Planning and Grid Issues

The previous IEA Wind Energy Annual Reports already described the constraints to market development ensuing both from the rather long time taken by local planning permissions and from the reinforcement of local electric networks needed for grid connection of large wind farm capacities. As a whole, these constraints have not yet been overcome.

Nevertheless, in these fields, some activities have been carried out by ENEA and ENEL, respectively, concerning local public information and the planning of new high voltage lines in the area of Southern Italy where most plants are or would be located.

At the moment people are generally in favor of the exploitation of wind energy

and such opinion could make it easier for investors to get the necessary permits from local municipalities in a relatively short time.

Considering all this, the target of 700 MW installed by 2000-01 could yet be achieved.

13.5.3 Institutional Factors

The Ministries of Industry (MICA) and of the Environment play an important role in the development of wind energy. In particular, MICA has been financing the activities carried out by ENEA concerning support to local administrations, siting, and certification. MICA has also, for some years now, been taking legislative measures devoted to increasing the dissemination of renewable sources.

As for POP funding (see above), for the time being only three Regions, Campania, Apulia and lately Sicily, are supporting the development of wind energy with a substantial contribution to plant capital cost.

13.5.4 Impact of Wind Turbines on the Environment

As in many other countries, the most important environmental issues for wind energy projects in Italy are generally visual impact, noise, and land use.

A true Environmental Impact Assessment (EIA) is not at present required by the Italian Law for wind energy projects, unlike other power plants. However, it is necessary for developers to identify the possible environmental protection constraints in the specific areas involved by contacting the local municipalities and the provincial and regional authorities.

However, something might change in Italy during the next few years following the implementation of the European Council Directive 97/11/EC of March 3, 1997. This Directive has added wind power plants to the list of projects for which an EIA procedure may be appropriate. Member states will have to determine whether wind energy projects must undergo an EIA procedure through a case by case examination or by setting suitable thresholds or in accordance with other criteria.

13.6 GOVERNMENT-SPONSORED R,D&D PROGRAMS

In past years, the state agency ENEA and the utility ENEL launched some R,D&D programs under the Government's coordination (acting through the Ministry of Industry, Commerce and Trade - MICA). Although ENEL is now in the process of re-orienting its activities according to a more commercial approach, information on already ongoing R,D&D programs is still given in this section for both organizations, as has been done in the past.

13.6.1 ENEA's R&D Program

Funding Levels

Within the framework of the MICA-ENEA agreement, about USD 3.3 million concerning wind activities were allocated in 1997. In comparison to the previous year there was a substantial reduction (more than 40%).

Ongoing Activities

The engagement of ENEA on renewable sources began in the early 1980s due to the decision of the Parliament to involve the Agency in various energy options. The activities, defined in a coordinated way with the central government, have since been carried out in collaboration with the other national operators of the field and within the framework of a wider research and development network, as well as at the international level. Such activities have aimed at constituting the technical-economic conditions for progressive exploitation of the renewable energy potential of the country, through the removal of the various barriers that

obstruct the spread of the various technologies.

Besides the promotion and development program on renewable sources, ENEA has also been called upon to cover new renewable sources, especially those technologies that offer, at the national level, a significant potential, both in the short term and in the medium-long one.

The activities that ENEA already carries out or is in a position to carry out can be synthesized as follows.

1. Research and technological development, in connection with the national industrial programs;
2. Qualification of the products;
3. Identification of the exploitable energy basins, at national and regional level;
4. Evaluation of environmental impact;
5. Public information;
6. Monitoring of the initiatives.

In 1997 a new activity began in the field of local public information. Some meetings were held by ENEA, also with an organizing support by the Apulia and Campania Regions and local authorities, in villages and communities involved in wind energy projects, in order to clarify the chances of development tied to the installation of wind farms, and the importance of taking into account the land characteristics. The aim was to minimize any possible environmental impact.

Other activities concerning siting and wind turbine certification have also been in progress. In 1997, the wind tunnel designed for certification purposes was completed at ENEA's Casaccia Centre near Rome.

International Collaborations

ENEA is engaged in Annex XVI of the IEA R&D Wind Agreement, entitled Wind Turbine Round Robin Test Program. Such activities are carried on in collaboration with research organizations from the United States, Canada, Denmark, and Greece.

Other international activities are likely to be launched within the framework of programs sponsored by the European Union.

13.6.2 ENEL's R,D&D Program

Funding Levels

The expenditure borne by ENEL for wind energy R,D&D activities in 1997 was around USD 5.5 million. This amount was less than was budgeted in the 1996 IEA Wind Energy Annual Report because of delays in some activities. The 1998 budget is around USD 5.7 million.

Wind Plant Siting

During 1997, ENEL's R&D Department (now SRI) has continued wind surveys and micrositing activities. This sector has seen a cooperation of SRI with the Conphoebus and ISMES subsidiary companies (which are part of the ENEL Group). Sites for about 100 MW are now at an advanced planning and permitting stage, which makes them exploitable by the ENEL Group for possible wind farming ventures in a short time.

Wind Turbine Testing

Testing activities have continued at the ENEL sites of Alta Nurra in Sardinia and Acqua Spruzza near Frosolone in Molise (Central Italy). The 1997 production was 1,007 MWh at Alta Nurra and 2,839 MWh at Acqua Spruzza.

At Alta Nurra, besides the running of medium-sized units installed in previous years, 1997 has seen the recommissioning of the 1.5-MW, 60-m-diameter GAMMA 60 prototype damaged by the fire in 1995. This prototype was built by WEST with support from ENEA. ENEL placed an order for its purchase but, at the time of the accident, the unit had not been taken

over yet. Significant effort was required to repair all damaged parts and to carry out, at the same time, a number of improvements suggested by a design review made jointly by ENEA and WEST.

After re-commissioning tests, the machine has been out of operation, waiting for ENEL to settle some contractual details with the manufacturer. ENEL's R&D Department considers the research work as already completed on this prototype, even though it could still be run for monitoring purposes.

At Alta Nurra, ENEL has also tested three stand-alone systems (two of which are of the hybrid wind-PV type) with batteries for supplying remote dwellings, in order to gain full experience that can enable the utility to draw up specifications for systems that are up to its power supply standards.

At Acqua Spruzza in Molise, performance monitoring and structural stress measurements have been in progress on eight medium-sized wind turbines of four different models, for a total power of 2.5 MW. Experiments have focused specially on the winter months to complete assessment of wind turbine behavior in a harsh climate at high altitude (1350 m). So far, experience has shown that such an environment can well pose problems, mainly from ice accretion (with consequent drop of performance of blades and anemometers), high turbulence (which brings about heavier fatigue stresses on machines), and lower machine availability (the personnel are sometimes prevented from reaching the plant for several days after snowfalls). All year round, other problems have resulted from frequent lightning over voltages. These have affected the centralized measuring, control and monitoring system, whose design had to be revised.

Test results from Acqua Spruzza have also been provided to international research projects financed by the European Commission within the framework of the JOULE program.

Demonstration Wind Farms

ENEL's first demonstration wind farm is located near Collarmele in Abruzzo (Central Italy) and is made up of 36 wind turbines supplied by Riva Calzoni, for a total capacity of 9 MW. After commissioning, a preliminary experimental operation period was also required by ENEL in 1997. After completion of this phase (in 1997 the plant produced 8,136 MWh), ENEL's R&D Department handed over the wind farm to the Production Division as a regular generating plant. (See figure 13.5)

Since September 1997, work has also been taken up again on ENEL's second demonstration wind farm at Monte Arci in Sardinia. This plant, 11 MW in capacity, was originally to be equipped with 34 wind turbines of the Medit type supplied by WEST. After completion of civil and electrical engineering work, the installation of wind turbines was put off in 1995 after WEST found some design defects on Medit machines at other, non-ENEL sites. WEST then developed a new version of Medit, named Lambda, featuring a teetering hub (instead of a rigid one) and other improvements. The first 14 Lambda units have now been set up at Monte Arci. The wind farm should be completed in the Spring of 1998 and then transferred to the Production Division.

Any further activities relating to the setting up of wind farms have been conferred upon ISMES, a subsidiary company of the ENEL Group. ENEL's R&D Department will however remain in charge of wind research and technology monitoring and will provide its technical assistance both inside the ENEL Group and, possibly, also to third parties.

International Collaborations

Internationally, ENEL's R&D Department has been involved in some projects funded by DG XII of the European Commission (JOULE Program). Among these, it is worth recalling that, also in 1997, ENEL played a major part in the EURE Utility Wind Farm Project, carried out by 14 European utilities. In particular, a feasibility study of wind farms with megawatt-class turbines at some European sites for a total capacity of 100 MW was completed in late 1997. ENEL's R&D Department has contributed to several parts of this job.

Figure 13.5 Some of the 36 single-bladed Riva Calzoni machines at ENEL's 9-MW Collarmele wind farm in Abruzzo (Central Italy).

CHAPTER 14

14.1 GOVERNMENT PROGRAMS

14.1.1 Aims and Objectives

As the necessities to cope with the problem of global warming as well as to guarantee our own energy security have increased, it has become indispensable to introduce new energy sources which have fewer resource and environmental constraints. Therefore, the government has expanded the policy on new energy sources during last several years.

The Long-Term Energy Supply / Demand Outlook established in 1990 was revised in 1994 to further improve energy conservation and promote the introduction of non-fossil energy resources such as renewable energy and nuclear energy.

In order to promote the introduction of new energy sources and to achieve the Long-Term Supply / Demand Outlook, the Basic Guideline for New Energy Introduction was established as a national policy in December 1994. It prescribes for the following:

Specification of the new energy sources to be introduced on a priority basis;

Determination of introduction targets for FY 2000 and FY 2010 and methods to achieve them for each new energy source.

On June 23, 1997, the Law on Special Measures for Promotion of Utilization of New Energy (New Energy Law) was enacted to accelerate the introduction of new energies for achieving the targets by FY 2000 and by FY 2010 It prescribes the following:

Formation and announcement of basic policies on new energy use;

Financial support measures for businesses which use new energy;

14.1.2 Strategy

In 1978, Japan started its wind energy R&D program, which is a part of the

Table 14.1 Installation of Wind Turbine Generating Systems in Japan.

YEAR	INSTALLED CAPACITY kW	TOTAL CAPACITY OPERATING kW	NUMBER OF INSTALLED UNITS	TOTAL NO. UNITS OPERATING
~1989	964.0	357.5	14	9
1990	633.0	890.5	4	13
1991	100.0	2898.5	1	23
1992	1908.0	2898.5	9	23
1993	2083.0	4941.5	12	35
1994	874.5	5856.0	6	41
1995	3640.0	9496.0	13	54
1996	3999.0	13495.0	16	67
1997	6543	20038.0	19	86

general R&D Program for renewable energy called the New Sunshine Project. It has been directed by the NEW Sunshine Program Promotion Headquarters (NSS H.Q.) in the Agency of Industrial Science and Technology (AIST) of the Ministry of International Trade and Industry (MITI).

In 1995, a national "Wind Power Development Field Test Program was initiated to attain the national target of the Basic Guideline for New Energy Introduction. The 50 % subsidy of plant cost under this Project has increased the installed capacity of wind power in Japan.

The New Energy Law enacted this year defines the measures to achieve the targets by FY 2000 and by FY 2010 for10 kinds of new energy fields such as solar energy, wind energy, clean energy cars, etc. Financial support measures for businesses are also defined.

14.1.3 Targets

The targets for wind energy are very small. They are 20 MW by 2000 and 150 MW by 2010. However, since the first target will surely be reached early in 1998, the numerical value will possibly be revised in the near future.

14.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

14.2.1 Installed Wind Capacity

During 1997, 6 units with 1386.5 kW of total capacity have been installed and another 13 units with 2756.5 kW of total capacity are under construction / planning. Therefore, it is expected that the total capacity of the wind turbine generators that are operating in Japan will exceed 20,000 kW in January 1998. Table 14.1 and Figure 14.1 show the time history of capacity of wind turbine in Japan.

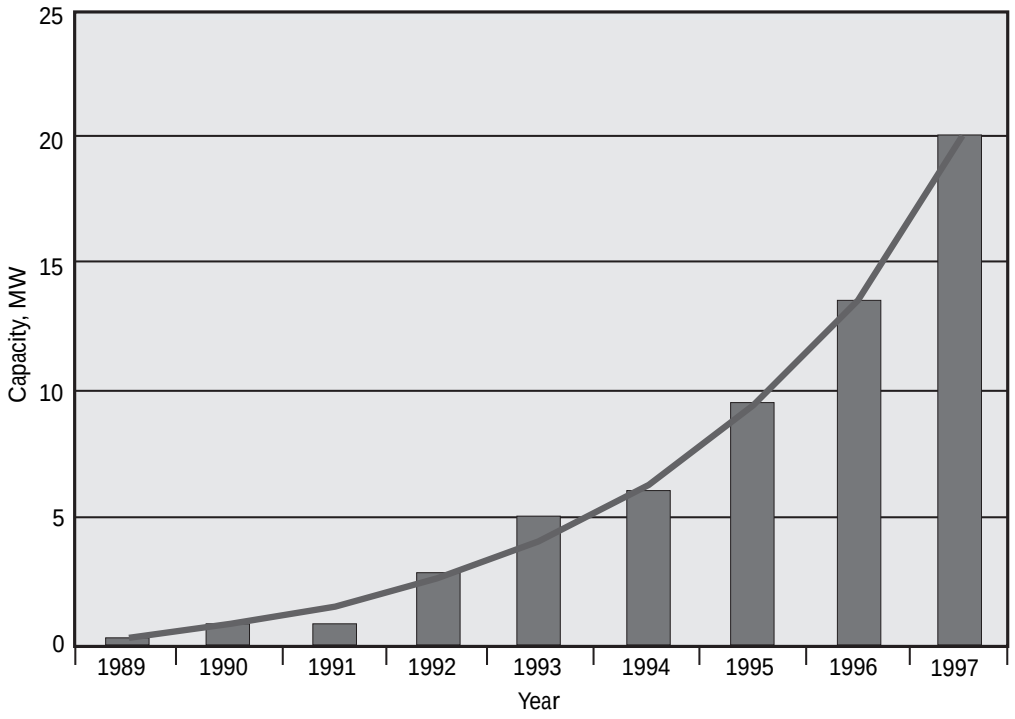

Figure 14.1 Time History of Capacity of Wind Turbine Generators in Japan

14.2.2 Installed Conventional Capacity

The amount of electric power generation in 1994 was 964.33 TWh. The features of the primary energy resources are shown in Table 14.2.

14.2.3 Numbers / Type, Make of Turbines

Shown in Table 14.3.

14.2.4 Plant Types and Form of Plant Ownership

Shown in Table 14.3.

14.2.5 Performance

In Table 14.4 performance data of some operating Wind turbine generators excluding Research machines are shown.

14.2.6 Operational Experience

There is limited operational experience in Japan. However it must be pointed out that siting and planning are very important. As is seen in Table 14.4, some plants recorded very poor capacity factors. This is mainly because the turbines were built at sites with very low wind speed, while the turbines have rather high rated wind speed. This combination destroys cost performance as well as turbine performance. Better understanding and a more scientific approach to siting and planning are needed.

14.3 MANUFACTURING INDUSTRY

The information that is available can be obtained from Table 14.3, in which all grid-connected commercial wind turbines are listed.

14.4 ECONOMICS

Because commercial wind turbine development is still at an early stage, a statistical evaluation of economics of wind generation in Japan can not be properly done. In general, wind energy generation is considered more expensive than conventional energy. Some example data are shown below.

14.4.1 Electricity Prices

The surplus electricity from wind turbine generators is purchased by electric power companies through contracts. The price is usually the same as that of house-hold customers, between 14.44 yen / kWh and 18.10 yen / kWh depending on the power companies and the season.

The cost of energy from wind generation was estimated as 32 Yen / kWh by the Agency of Natural Resources and Energy a couple of years ago. This means the cost of wind generation is about 3 times more expensive than that of other conventional energies.

Table 14.2 Features of the Primary Energy Resources of Japan (in 1994).

Distribution Ratio of Primary Energy Resources	Percent
Oil	55.9
Coal	16.3
Nuclear	14.6
Natural Gas	10.6
Others	2.6
Contribution Ratio of Imported Energy Resource	81.5
Contribution Ratio of Imported Oil	99.7

Table 14.3 List of Wind Turbine Generator Systems in Japan, 1996 and 1997.

START DATE	OWNER	LOCATION	RATED POWER kW	NO. OF UNITS	MACHINE	PURPOSE
1996	Yamgata Wind Power Institute	Yamagata Pref., Tachikawa-Chou	400/100 kW	2	Micon	Power supply
1996	Choguko TPC	Yamaguchi Pref., Heki-cho	300/100 kW 107.5 kW	1 1	MHI Kenetech	Demo.
1996	Kansai EPC	Hyougo Pref. Ikuno-machi	150/30 kW	1	IHI/Nordex	Demo.
1996	Shizuoka Pref.	Shizuoka Pref., Omaezaki-machi	300/100 kW	1	MHI	Power supply
1996	Sado Natural Energy Institute	Niigata Pref., Kanai-machi	225/40 kW	1	Micon	Demo.
1996	Nadachi Wind Power Station	Niigata Pref., Nadachi-machi	400/100 kW	2	Micon	Power supply
1996	NTT	Hiroshima Pref., Oogaki-machi	16.5 kW	1	Yamaha	Power supply
1996	NEDO/Tohoku EPC	Aomori Pref., Tappi-machi	500 kW	1	Yamaha	Power supply
1996	Erimo Wind Power Institute	Hokkaido Erimo-Choi	400/100 kW	2	Micon	Power supply
1997	Hebiura Wind Power Station	Aomori Pref., Kazamaura-mura	400/100 kW	1	Micon	Power supply
1997	Toyota Auto.	Aichi Pref., Tahara-machi	16.5 kW	1	Yamaha	Display
1997	NEDO/Arco Co.	Kanagawa Pref., Miura-shi	400/100 kW	2	Micon	R&D/Power supply
1997	NEDO/Tabashine Assn.	Iwate Pref., Hiraizumi-cho	490 kW	1	MHI	R&D/Power supply
1997	Hokkaido Kaihatsu kyoku	Hokkaido Ishikari-shi	80 kW	1	TACKE	Power supply

Table 14.4. Performance Data of WTGS in Japan (1996).

OWNER	LOCATION	RATED POWER, kW	WIND GENERATION kWh	CAPACITY FACTOR 1996
Kyushu EPC	Kagoshima Pref., Kami-Koshiki-Jima	250	434450	0.198
Seto-Cho	Ehime Pref., Seto-cho	100	108309	0.124
Tohoku EPC	Aomori Pref., Tappi-Misaki	2675 (3375)	7880000 (FY1996)	0.302
NEDO/Okinawa EPC	Okinawa Pref., Mikayo Is.	500	1330580	0.304
Chubu EPC	Aichi Pref., Hekinann-shi	250	126400	0.058
Izumo-shi	Shimane Pref., Izumo-shi	33	45145	0.156
Mattou-shi	Ishikawa Pref., Mattou-shi	100	87454	0.100
Tachikawa-Chou	Yamagata Pref., Tachikawa-Chou	300	1266336	0.048
Tokyo EPC	Chiba Pref., Futtsu-shi	300	94625	0.036
Hokkaido EPC	Hokkaido Tomari-mura	1100	1343808	0.139
Hokuriku EPC	Fukui Pref., Mikuno-cho	16.5	13043	0.090
Hokuriki EPC	Ishikawa Pref., Shiga-machi	275	142997	0.059
Shikoku EPC	Kouchi Pref., Muroto-misaki	300	264540	0.201
kanto-Kokusai Gakuen	Chiba Pref., Katsuura-shi	250/50	123115	0.056
Kouchi Pref., Industrial Dep.	Kouci Pref., Noichi-machi	250/50	148487	0.068
Heiwa Kanko	Fukushima Pref., Tenei-mura	450	681517	0.173
Yamagata Wind Power Institute	Yamagata Pref., Tachikawa-Chou	800	1094024	0.156

Table 14.5 Trial Price Estimation.

ANNUAL MEAN WIND	250 kW MACHINE	400 kW MACHINE
6 m/s	15.46 yen/kWh	14.79 yen/kWh
7 m/s	10.04 yen/kWh	9.45 yen/kWh
8 m/s	7.72 yen/kWh	7.17 yen/kWh

In 1996, the New Energy Foundation reported as shown in Table 14.5.

14.5 MARKET DEVELOPMENT

14.5.1 Market Stimulation Instruments

Aiming at developing 150 MW capacity by 2010, MITI / NEDO's national Wind Power Development Field Test Program started in 1995. This program provides incentives to develop wind markets in Japan and has raised interest in wind energy among developers, local authorities, private companies / persons, etc.

The New Energy Law that was newly enforced this year prescribes further measures of accelerating the introduction of new energies. In the law, "New Energy" is defined as oil-

alternative energy sources that have not yet been widely used due to economic constraints, but whose introduction is necessary in order to reduce Japan's oil dependence.

Table 14.6 shows the new energy installation record and targets for various kind of new energies, in which targets are shown in MW or in kl (oil equivalent). "Clean energy vehicles" mean electric vehicles, natural-gas vehicles and methanol-fueled motor vehicles.

The incentive measures for introducing wind energy in Japan are summarized in Table 14.7.

The capacity of wind power plants covered in the New Energy Law is 800 kW or above for private business entities and 1200 kW or above for municipal corporations or related companies with municipal corporations.

14.5.2 Planning and Grid Issues

In Japan, the problem of complex terrain is rather large. The resulting gusty and turbulent winds affect the design of turbines for mechanical strength and electrical quality of output power. Also complex terrain increases the cost of transportation, erection, and grid-connection. The higher cost of wind plants on average in Japan is mostly attributed to these factors.

On the other hand, as mentioned above, improved siting and planning could improve performance of newly installed turbines. In the past a lack of scientific understanding brought very poor operational data.

14.5.3 Institutional Factors

Besides the institutional progress mentioned above, important changes in electricity regulations in 1992 have had a worthwhile effect as well. Reverse current was permitted for the first time, which allowed utilization of grid-connected wind turbine generators. However, even though the price can be determined through negotiation with a one-year contract between the developer and electric power company, still there is no law that settles the duty and price of purchasing wind energy. Therefore, it is difficult to establish a stable wind energy business.

Table 14.6 New energy installation record and targets.

TECHNICAL AREA	FY 1995 RECORD	FY 2000 TARGET	FY 2010 TARGET
SUPPLY SIDE NEW ENERGY SOURCES			
Photovoltaic power generation	39 MW	400 MW	4600 MW
Wind power generation	9 MW	20 MW	150 MW
Thermal energy conversion	19 x 10^3 kl	200 x 10^3 kl	580 x 10^3 kl
Waste power generation	810 MW	2000 MW	4000 MW
Solar heat utilization	1090 x 10^3 kl	3000 x 10^3 kl	5500 x 10^3kl
Thermal use of waste	41 x 10^3 kl	70 x 10^3 kl	140 x 10^3 kl
Others	4790 x 10^3 kl	5050 x 10^3 kl	5930 x 10^3 kl
Combined share of total primary energy supply	7020 x 10^3 kl (1.1%)	5050 x 10^3 kl (2.0%)	19100 x 10^3 kl (3.0%)
DEMAND SIDE NEW ENERGY SOURCES			
Clean energy vehicles	4 x 10^3 kl	440 x 10^3 kl	2220 x 10^3 kl
Cogeneration using natural gas	1290 MW	2670 MW	4550 MW

14.5.4 Impact of Wind Turbines on the Environment

So far no significant environmental problems have occurred. It is because the history of wind farm development is very young in Japan. At Tappi Wind Park, a complaint of noise was once reported, but it was solved by soundproof construction.

Regarding birds, the behavior of migratory birds was once observed by Tohoku EPC. According to the report, the birds are clever enough to recognize the rotating blades and no bird has been killed by the Wind turbine generators at Tappi Wind Park so far.

14.5.5 Financing

The New Energy Law provided some tax benefits this year.

14.6 GOVERNMENT-SPONSORED R,D&D PROGRAMS

The outline of the national wind energy activities in Japan is shown in Table 14.8.

14.6.1 Funding Levels

Table 14.9 shows the history of the budget for wind energy R&D in the NSS Project and Field Test Program .

14.6.2 Priorities

14.6.2.1 New Sunshine Project : Research & Development

In 1978, Japan started its wind energy R&D program which is a part of the general R&D Program for renewable energy called the New Sunshine Project. It has been directed by the NEW Sunshine Program Promotion Headquarters (NSS H.Q.) in the Agency of Industrial Science and Technology (AIST) of the Ministry of International Trade and Industry (MITI). In this program, the following activities have been conducted:

Wind resource measurement (Now transferred to Wind Power Development Field Test Program);
R&D of large-scale wind turbine generator systems.
Demonstration of a MW-class power plant;
R&D for basic innovative technologies.

Table 14.7 The Incentive Measures for Introducing Wind Energy in Japan.

INCENTIVE TYPE	SYSTEM	RECIPIENT	SUBSIDY MEASURES
SUBSIDY			
SURVEY	Investigation into regional energy development	Municipal corporations or related companies	Subsidy rate of 1/2 or less
	Investigation into model projects for providing against greenhouse gases	Municipal corporations	Ecotopia Subsidy rate of 1/2
	Project for developing regional new-energy vision (founded in 1995)	Municipal corporations Municipal corporations	Subsidy rate of 100%
PROJECT	Model power generation projects for regional energy development	Municipal corporations and private businesses	30% or less
	Projects for power generation implementation (distant areas and islands)	Agricultural cooperative association and other organizations	1/3
	Wind power development field test program (founded 1995; wind measurement, system design and construction operation)	Municipal corporations and private businesses	100% for wind measurements 50% for the rest
FINANCING	Project for encouraging power generation for regional energy development and utilization	Municipal corporations and private businesses	100 million yen or less Interest rate of 3% covered
TAXES			
NATIONAL TAX	Tax system for encouraging investment focusing on structural innovation of energy demand and supply	Persons and business entities that file blue returns	Tax subtraction of 7% or special depreciation of 30%
LOCAL TAX	Tax system for local energy	Persons or corporations engaged in business system for local energy	Reduction in imposed standard tax of 1/6

Table 14.8 National Wind Energy Activities in Japan.

NATIONAL ACTIVITIES	ORGANIZATION/INSTITUTE
New Sunshine Project (R&D)	NSS-H.Q.
1. Wind resource measurement	NEDO
2. R&D of LS-WTGS (500 kw)	NEDO/MHI/Tohoku EPC
3. Demonstration of a MW-class wind farm	NEDO/Okinawa EPC
4. Generic, innovative R&D (WINDMEL-I, -II, Aerodynamics)	MEL
Wind Power Development Field Test Program (Demo)	MITI/NEDO
New Promotion Project	MITI?NEDO
Standard (IEC, ISO, JIS)	MITI/MEL/industries/etc.

The New Energy and Industrial Technology Development Organization (NEDO) carries out the first three, while the last one is undertaken by Mechanical Engineering Laboratory (MEL) , AIST, MITI and support the first three mainly through technology evaluation.

After completion of the 100 kW pilot plant in 1986 and further research for a large-scale wind turbine, a new R&D program to develop a 500 kW class wind turbine prototype was initiated in 1990. Conceptual design of the 500 kW prototype was completed in FY 1992. In FY 1994 and 1995, some components of the 500 kW wind turbine were tested by Mitsubishi Heavy Industry Ltd.(MHI). Full scale fatigue testing of the rotor blades was carried out to verify the blade design. Load testing and noise measurement of the gear box and modal analysis of the nacelle cover by FEM were undertaken. It has a three-bladed, 38m-diameter rotor mounted to a rigid hub.

In October, 1996, the machine was erected on a hilly site in the center of Tappi Wind Park owned by Tohoku EPC (Figure 14.2). On October 15, the turbine was damaged by a lightning strike. Its sensors, a part of control system, and other apparatus were damaged, but it was repaired and operation started on October 21. A series of field tests are now underway. The main items of the tests are:

Reliability tests of the wind turbine generators and its components;
Performance tests: wind turbine generators, Pitch control system;
Grid connection system Aerodynamics of rotor blades;
Construction / Vibration tests;
Data acquisition and Economics analysis;
Noise measurement.

In July 1997, the system was shut down due to abnormal noise from the gear box. Inspection revealed that the gear box was damaged by a metal element. It is now under repair.

Table 14.9 Budget for National Wind Energy Projects in Millions of Japanese Yen (JPY).

YEAR	1991	1992	1993	1994	1995	1996	1997
NSS project	549	981	982	744	635	608	556
Wind Power Development Field Test Program	–	–	–	–	80	320	460
Total	549	981	982	744	715	928	1016

14.6.2.2 Demonstration of a MW-class Wind Farm (Miyako Project)

An experimental MW-class wind farm of 1.7 MW rated power was completed in October 1995 on Miyako Island in Okinawa. The wind farm consists of two units of MHI-250 kW wind turbine generators and three units of Micon 400/100-kW Wind turbine generators. One of the purposes of this project is to demonstrate the availability of wind energy connected to a grid of small capacity on such an island. The site is an open narrow flat cap covered by ocean with open 7 m/s of annual mean wind speed. The highest record of monthly capacity factor was 53.2% obtained in December 1994. The annual capacity factor in 1996 was 31.1%. (See Table 14.10)

14.6.2.3 Wind Power Development Field Test Program

To attain the national target of the new energy/environmental policy, in which wind energy shall be promoted up to 150 MW capacity by 2010, national NEDO's Wind Power Development Field Test Program was started in 1995. In the project, subsidies from the government are provided for those who are active in developing wind power plants. The term of a project is five-years. In the first year, meteorological measurement is under taken with 100 % of subsidy. In the second year, an optimized wind power plant is designed with a subsidy up to 50% of the design cost, if the wind measurement proved to be available enough for wind power generation. In the third year, the wind plant is constructed with a subsidy up to 50%.

Among many candidates who apply to this Wind Power Development Field Test Program, more than ten are subsidized for wind measurement, while a few are subsidized for plant design and construction.

14.6.2.4 IEC Standard and JIS Standard

The national programs include cooperation in IEC Standard activities in the wind energy category. MITI also promotes the policy to have international consistency in standards. Therefore, national JIS standards for wind turbine generator systems are also on the table for publication in the near future in parallel with IEC standards.

14.6.3 New Concepts

Under the NSS's R&D Program, MEL, a national laboratory that has been carrying out generic research since 1978, has tested the fully flexible wind turbines, WINDMEL I and WINDMEL II. As a technical result of the research operation of the WINDMEL II, the concept of flexible

Table 14.10 Operational Data of the Miyako Wind Power Plant (two units of MHI 250-kW machine).

YEAR	WIND SPEED (m/s)	GENERATION (MWh)	CAPACITY FACTOR (%)
1992*		371,510	20.0
1993		1,000,740	22.8
1994	7.6	1,247,280	28.5
1995	7.1	1,361,990	31.1
1996		1,362,490	31.1

*One unit

blade design proved to have an advantage in reduction of mechanical stress, as well as in stabilization of output power.

14.6.4 MW-rated Turbines

We have studied MW-scale wind turbines, but so far there is no R&D program. The main question involves transportation and construction in the restricted conditions of our roads and mountainous topography.

14.6.5 Offshore Development

Although Japan could develop offshore or semi-offshore wind farms, it is not so urgent as in European countries because a lot of potential candidate sites for wind turbines on land remain undeveloped.

14.6.6 International Collaboration

The main activities for Japan are IEA Wind R&D cooperation and IEC standard of wind turbine generators. Many individual international collaborations are undertaken at research institutes and universities.

14.6.7 Wind Energy Resources

In 1994, NEDO completed a new wind database for wind energy development which covers the data at 737 stations in the national local meteorological observations network system (AMeDAS) and those at 38 NEDO locations. In total, data from 964 stations were analyzed to create a wind atlas. In 1995, the Japan WIND ATLAS was published by NEDO.

The wind energy potential is shown in Table 14.11. The minimum and maximum values correspond to the array conditions of wind turbine generators in a wind farm of 10D x 10D and 10D x 3D respectively, where D is the diameter of a wind turbine generators. According to scenario 2, which is a moderate one, it is expected that a contribution of a few percent of the electricity demand in Japan can be supplied by wind.

Table 14.11 Wind Energy Potential in Japan.

SCENARIO	AREA km^2 (ratio to total land surface in %)	POTENTIAL NUMBER OF UNITS*	POTENTIAL CAPACITY MW (ratio to total in %)	POTENTIAL WIND GENERATION GWh (ratio to total generation in %)
1	23,280 (6.4%)	125,519 – 565,278	not completed	not completed
2	3,599 (1%)	18,430 – 70,481	9,220 – 35,240 (4.61% – 17.62%)	8,916 – 34,127 (1% – 3.84%)
3	759 (0.2%)	2,792 – 13,743	1,440 – 6,870 (0.7% – 3.43%)	1,325 – 6,537 (0.15% – 0.74%)

CHAPTER 15

15.1 GOVERNMENT PROGRAMS

Legislation regarding electricity production for public service was modified in 1992 to allow independent power production and other forms of private generation. Nowadays, private investors are allowed to build and operate electric power stations for either self-supply or electricity sale to the Federal Electricity Commission (CFE), the government-owned electric utility. Current environmental and energy policies share the aim of sustainable development. Therefore, the energy sector is seeking appropriate strategies for the implementation of wind energy in Mexico, which could foster the creation of jobs and regional development and promote private investment.

Specific targets for wind capacity have not been announced by the government, but large-scale implementation of wind energy is just starting. However, promoters of wind energy, which include the working teams on renewables from government-owned institutions (e.g. the Electrical Research Institute (IIE), the Federal Electricity Commission (CFE), and the National Commission for Saving and Efficient use of Energy (CONAE)), have pointed out that the exploitation of the main wind resource in Mexico could lead to 5000 MW of new, clean power.

The best wind resource is found south of the Tehuantepec, in a 3000 km^2 region known as "La Ventosa." Annual mean wind speeds from 7 to 11 m/s at 30 m height have been measured at some sites in this region. It is estimated that up to 2000 MW of wind farms could be installed there with technical and economic advantages.

15.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

During 1997, no additional wind capacity was connected to the National Electric System (SEN). Therefore, the total installed wind farm capacity remains at 1.575 MW, corresponding to a demonstration project commissioned in the middle of 1994, at "La Venta," Oaxaca. This power station was bid as a "turn key" project by CFE who owns and operates the facility.

"La Venta" wind farm has seven 225-kW Danish wind turbines (Vestas V27). During 1996, electricity production from this power station was 5 Gwh, with a capacity factor of 36%.

A new project in "La Ventosa" has been announced by CFE. This project, known as "La Venta II," would have a 54 MW capacity and, if built, it would be the first large-scale wind farm owned by the public sector in Mexico. No firm dates have been announced to start this project. Currently, CFE is working on a smaller project at a site known as "Guerrero Negro" on the Baja California Peninsula, where a 600-kW wind turbine will be installed in early 1998. The turbine will operate in parallel with a bank of diesel generators rated at 16 MW. Plans are underway to expand the wind capacity at this site to 3 MW.

At least two wind farm projects are under development by private companies in association with municipalities. The first one is a 30-MW wind farm to be installed on Cozumel Island in southeast Mexico. The second is a wind farm of 27 MW to be built at "La Ventosa." Both projects are in the modality of electricity self-supply. Permits to build both projects have already been granted, but a number of

negotiations are still pending before the ground is open for construction.

Conventional generating capacity installed in Mexico as of October, 1995 was 34,287 MW, built up as follows: oil plus natural gas (54.2%), hydro (27.7%), coal (7.5%), oil/coal (6.1%), nuclear (3.8%), and geothermal (2.2%). During 1996, electricity production from conventional capacity was 151.9 TWh. The need for new capacity to 2005 was forecast in 1996 to be 12,761 MW.

15.3 MANUFACTURING INDUSTRY

At present, there is no wind turbine manufacturing industry in Mexico, except for one company that makes a small 6-kW machine. However, there is an increasing interest from private investors to establish wind turbine manufacturing joint ventures. Several wind turbine components (e.g. towers, nacelles, electrical parts, cables, transformers, and others) could be manufactured in Mexico using existing infrastructure. It is expected that deployment of wind energy in Mexico could be impelled by a meaningful level of activity in local wind turbine integration.

15.4 ECONOMICS

Electricity price to consumers varies depending on the region, the time of the day, and the supply voltage. For electricity billing purposes, the country is divided into eight regions. Each region has its own timetable for electric tariffs along the day. Examples of electricity prices (active in December, 1997) valid for the whole country, are given in Table 15.1.

Domestic customers pay MEP 0.310 for each of the first 75 kWh, 0.362 for each kWh in excess of the first 75 kWh, and 1.036 for each kWh in excess of the first 200 kWh.

No special buy-back price for wind energy has been set in Mexico. Hence, prices for electricity from wind energy to be paid by CFE would be based on the active tariffs. This means that the revenues from a wind farm project in Mexico would depend not only on the amount of electricity generated, but also on the time of the day this electricity is fed into the grid.

According to CFE, generation costs from "La Venta" wind farm are near USD 0.043 per kWh, while the total installation costs for this facility were around USD 1,250 per kW. Generation costs from "La Venta," according to CFE, are similar to generation costs from big thermal power stations in Mexico.

15.5 MARKET DEVELOPMENT

The main constraints for wind energy market development in Mexico are typical of the starting phase of similar programs around the world. Ad hoc market incentive mechanisms and planning strategies are being sought, but there are several barriers to overcome.

The Ministry of Energy is sponsoring some projects and activities in this direction. It is expected that results will be seen within the next few months. Meanwhile, private investors continue their activities to develop wind farm projects at those sites and opportunity niches where the present conditions could lead to feasible projects.

Table 15.1 Examples of electricity prices in Mexico (MEP, December 1997).

VOLTAGE RANGE (kV)	PEAK	INTERMEDIATE	BASE
$1 > V < 35$	0.77-0.96	0.26-0.36	0.20-0.26
$35 > V \leq 220$	0.74-1.04	0.24-0.34	0.21-0.25

CHAPTER 16

16.1 GOVERNMENT PROGRAMS

16.1.1 Aims and Objectives

The targets of the energy policy of the Netherlands are laid out in the Third Energy Memorandum, issued December 1995, by the Ministry of Economic Affairs. Results should be an overall stabilization of CO_2 emission and fossil fuel use (at the level of 1990). This is necessary because of the limits to fossil fuel sources, increasing vulnerability of the energy supply, and international environmental problems, specifically imminent effects of climatic change.

The road to follow is organized according to the so called Trias Energetica which says: First limit energy demand as much as possible, then meet the remaining demand with renewable energy. Finally if fossil fuels are still required use them cleanly and efficiently.

To save energy, the memorandum announces initiatives for an improvement in energy-efficiency of one third of the energy use in the next 25 years. Sustainable energy will contribute 10% in annual saving of fossil fuels in 2020 through initiatives like green electricity, green funds, a fair pay-back rate, and an action plan for intensified R,D&D efforts. Most efficient fuel use is pursued by installing combined heat and power, gas fueled new generating plants, and developing clean technology for coal fired plants. Building new nuclear plants is not an option for the coming years.

The Third Energy Memorandum also sets out the policy for a liberalized energy market. It announces a network authority for electricity and natural gas, gradually more freedom of choice for end users, and fair competition rules. The announced Energy Report for the year 2000 will analyze and judge development of long term supply and demand and give a facility to influence desired penetration of sustainable energy sources and energy conservation. It announces a new Electricity Act.

The budgets per year (to be built up in a few years) are:

1. From the Ministry of Finance for fiscal incentives: 175 million NLG: green funds, Accelerated Depreciation on Environmental Investment, Energy Investment Deduction and green VAT, and
2. From the Ministry of Economic Affairs budget: 40 million NLG for research and development, and 45 million NLG for demonstration and market introduction.

At present, not more than 1% of Dutch energy consumption is met by renewable sources such as solar, wind, and water. The Memorandum set the targets for renewables at a 3% contribution in 2000 and a 10% contribution in 2020. The targets have been set in annual saving of fossil fuels, expressed in petajoules (see Table 16.1). Total national energy consumption is 2,700 PJ.

16.1.2 Strategy

The strategy to reach the targets of the Third Energy Memorandum was laid out in the action plan *Renewable Energy on the March* (DEIO) published in March 1997 by the Ministry. This plan stresses the need for an accelerated effort of concerned parties and sums up the measures that are required in the years till 2000 under three themes:

Improving the price-performance ratio;
Stimulating market penetration;
Addressing administrative bottlenecks.

16.1.2.1 Improving the Price-Performance Ratio

This is primarily a 'technology push' operation. If renewable energy is ultimately to compete with fossil fuels such as gas and oil, the key is technological development. To improve the price-performance ratio, research, development and demonstration is essential. The following actions have been started:

Execution of long term research programs in the field of wind energy, solar energy, and energy from biomass and heat pumps;
Execution of the Economy-Ecology-Technology program;
Intensifying the participation in European research programs.

16.1.2.2 Stimulating Market Penetration

This is primarily a market pull operation. To promote market penetration of those renewable energy options that are on the verge of becoming economic, the following actions have been started:

Broadening the range of fiscal instruments;
Reaching agreements with EnergieNed, the association of energy distribution companies in the Netherlands, about the activities they are to undertake in the period 1997-2000 in order to promote renewable energy;
Improving the export instruments for renewable energy products;
Setting up the Renewable Energy Project Bureau in 1997;
Amending the new draft Electricity Act in such a way as to allow a minimum share of renewable energy in the electricity supply to be mandatory as from the year 2001;
Publication of the energy report, stating the percentages of mandatory minimum shares of renewable energy for the period 2001 - 2005.

16.1.2.3 Addressing Administrative Bottlenecks

This is primarily an operation focusing on the planning and decision making process. When a given option is ripe for the market and capable of large-scale application administrative bottlenecks can arise. The following actions are therefore to be taken to remove those bottlenecks:

Extension, broadening and deepening of the Administrative Agreement on Location Problems Wind Energy between the government and regional authorities;
Promotion of combined use of space for nature, agriculture, infrastructure and wind energy;
Incorporation of large scale locations in the Electricity Supply Master Plan, in consultation with regional authorities;
Drawing up an Off shore Wind Energy Location Plan.

16.1.3 Targets

The official target for wind energy is set in annual avoided fossil primary energy in petajoules (see Table 16.1). This translates roughly in needed installed capacity according to the following table.

From the 2,750 MW in 2020 it is expected that around 1,500 MW will be installed offshore. (See Figure 16.1)

16.2 COMMERCIAL IMPLEMENTATION OF WIND POWER

16.2.1 Installed Wind Capacity

During 1997, 90 turbines with a total of 44 MW were installed and 51 turbines with a total of 14 MW were removed bringing the total operational capacity by the end of 1997 to 325 MW with 1,144 turbines and 764,934 m^2 swept area. (See Figure 16.2.)

16.2.2 Numbers/Type, Make of Turbines

The average installed capacity per turbine in 1997 was 492 kW, average ratio between swept area and capacity was

Table 16.1 Renewable Energy Targets in Annual Avoided Fossil Primary Energy (PJ)

SOURCE	2000	2007	2020
Wind Energy	16	33	45
Solar Energy PV	1	2	10
Solar Energy Thermal	2	5	10
Hydro Power	1	3	3
Biomass (incl. waste)	54	85	120
TOTAL RENEWABLES	74	128	188
Geothermal	0	0	2
Cold and Heat Storage	2	8	15
Heat Pumps	7	50	65
TOTAL SUSTAINABLES	9	58	82
RENEWABLES AND SUSTAINABLES	83	186	270

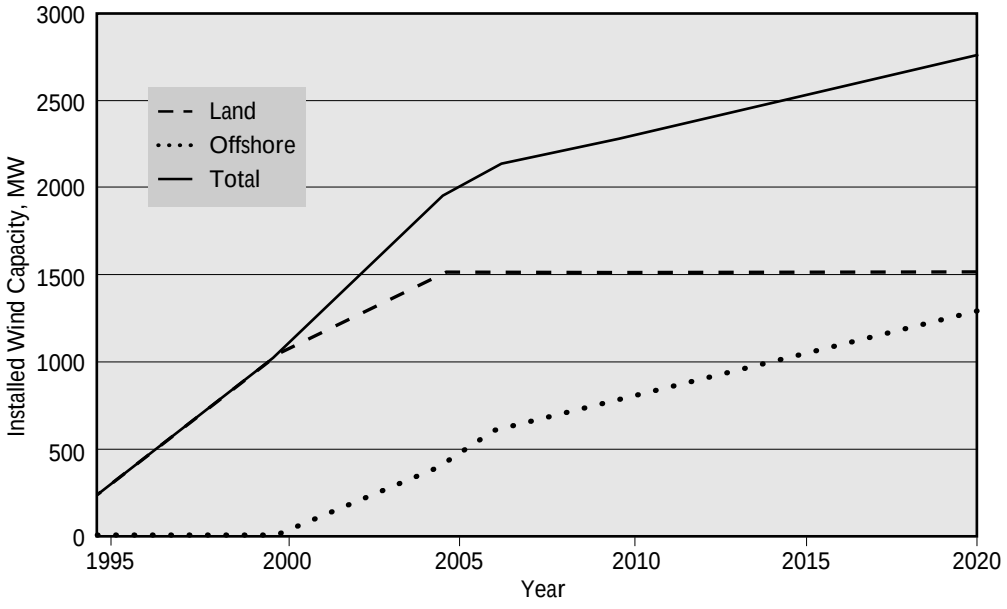

Figure 16.1 Expected wind capacity 1995–2020.

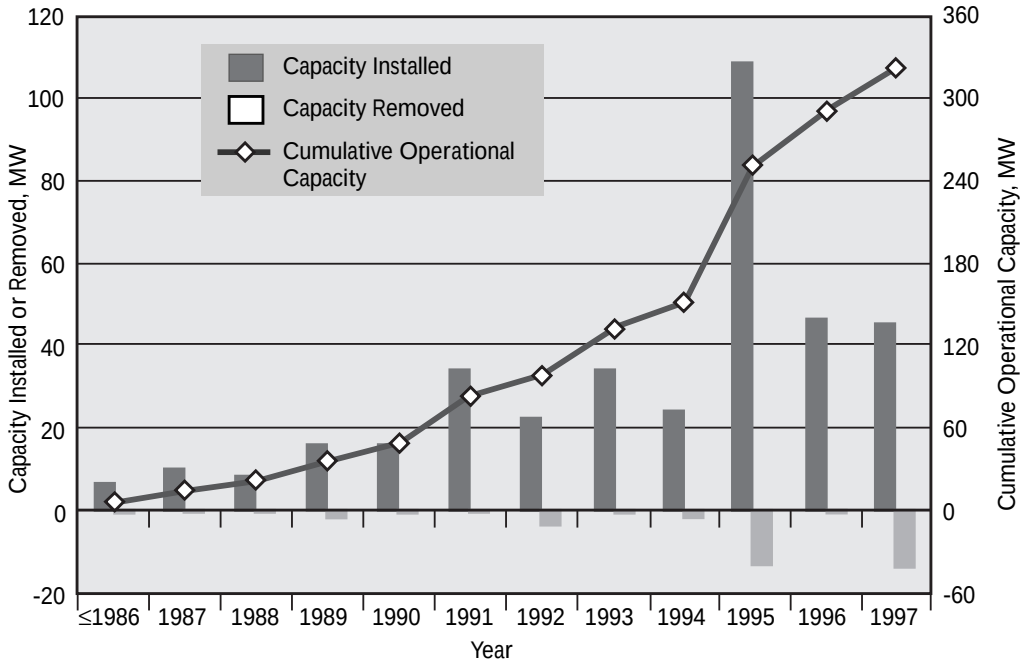

Figure 16.2 Installed, removed, and operational wind capacity.

2.4 m^2/kW and average hub height 42 m. (See Figure 16.3)

Of the installed capacity in 1997, 41% was manufactured in the Netherlands, the remaining was from Denmark as shown in Table 16.3.

Removed were 35 HMZ WindMaster 300 kW/25m turbines, which were replaced with the 18 WindMaster 750 kW/45m turbines and 14 Bouma 250kW/25m which were replaced with 14 Vestas 225kW/27m machines.

Table 16.2 Targets for Wind Energy.

YEAR	CAPACITY MW	SAVED PRIMARY FUEL, PJ
1990	50	0.6
1995	250	4
2000	750	12
2007	2000	33
2020	2750	45

16.2.3 Plant Types and Form of Plant Ownership

The new wind capacity consists of 2 medium sized, 7 small wind farms, and 12 individual machines according to Table 16.4.

Of the installed wind turbines, 53% are owned by utilities and 31% by limited companies.

16.2.4 Performance of Installed Plants

In 1997 electricity production from wind energy was 451 GWh or 0.6% of national electricity consumption and it avoided 3.9 PJ in fossil fuel.

Like 1996, 1997 also had a Windex of 68% which classifies it as a bad wind year. The 30-year average is set at 100%. The average of the last 10 years was 88%.

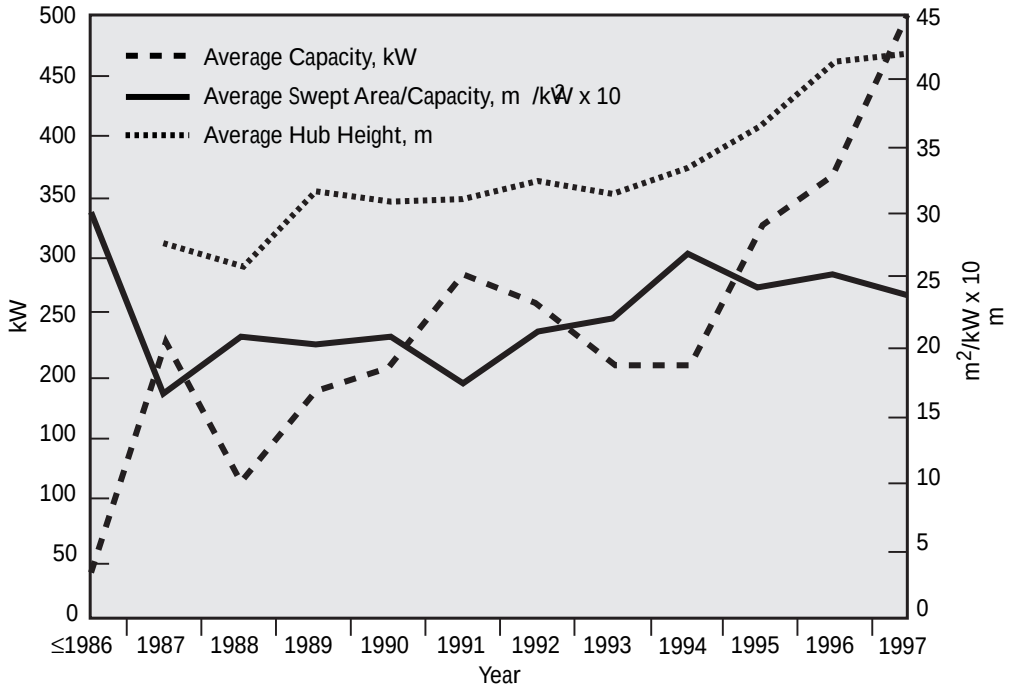

Figure 16.3 Average capacity, swept area / capacity, and hub height of installed turbines per year.

Average specific production in 1997 was 645 kWh / m^2, corrected for the year long average it should be 950 kWh / m^2. In an average wind year, the installed capacity of 325 MW with a swept area of 764,934 m^2 could produce 725 GWh and avoid 6.3 PJ.

Monthly energy production from wind energy can be found at the internet site http: / / www.kema.nl / kema / wind-novem.htm.

16.2.5 Installed Conventional Capacity And Electricity Consumption.

Installed conventional capacity in 1997 was around 18 GW of which around 3.5 GW came from decentralized combined heat and power plants. The maximum load of 11,785 MW occurred on December 17.

Electricity consumption increased 3.2% in 1997, bringing the total to 81,170 GWh. Of this 70% was produced in centralized plants, 15% was imported, and 15% was generated in combined heat and power plants.

16.2.6 Operational Experience

There were no major accidents or incidents in 1997.

16.3 MANUFACTURING INDUSTRY

16.3.1 Status / Number / Sales of Manufacturers

The number of Netherlands wind turbine manufacturers has not changed over the last 5 years. They are Lagerwey, NedWind and WindMaster.

The three Netherlands blade manufacturers are Aerpac, Polymarin and Rotorline. Most of their blades were supplied to Dutch, German, Danish, Spanish and U.S. wind turbine manufacturers.

Table 16.3 Distribution of New Turbines by Manufacturer.

MANUFACTURER	TURBINES	INSTALLED MW	INSTALLED %	ROTOR AREA m^2
WindMaster	18	13.5	30	26.140
Vestas	24	9.0	20	23.620
NedWind	19	4.8	11	14.341
Nordtank	16	9.6	22	23.235
Bonus	13	7.5	17	19.102
Total New	90	44.3	100	106.437

In 1997, about 360 people were employed directly by the wind turbine and blade manufacturers.

It is estimated that another 400 were employed with subcontractors, consulting firms, service companies, research institutes and universities.

16.3.2 New Products / Technical Developments

The prototype of the Lagerwey direct drive 750 kW turbine was fitted with a 50 m instead of a 45 m diameter rotor and tests started in the last quarter of 1997.

WindMaster is designing a range of machines for high and low wind speed regimes. They will have capacities from 600 to 900 kW with variable speed, 3 blades, pitch control, and full network adaptable abilities.

Blade manufacturers are developing their product range for machines of 300 kW, 600 kW, 850 kW, 1 MW, 1.5 MW and further. They adapt their designs for stall and pitch regulated, constant and variable speed machines. Aerpac supplied its first blade set for a 60 m diameter machine.

Industry and researchers foresee the following trends for 2001:

1. Evolution of existing concepts towards bigger machines of 1.5 to 3 MW and resolving the related transport problems.
2. Meeting higher requirements on quality of electricity, e.g. power factor, voltage and power stability.
3. The first offshore turbines will be derived from existing technology. Future turbines will be designed for site specific conditions.
4. Improved price-performance ratio through economies of scale, shorter time to market and increased reliability.
5. Aerodynamics and aeroeleastics will remain the main R&D topics for the next decade.

16.3.3 Business Developments

The shares of WindMaster Nederland have been bought by WindMaster management and a group of American investors. The controlling stake was bought from the Dutch Begemann Group.

16.3.4 Support Industries

Two new developers started activities in 1997. Work for engineering firms is

Figure 16.4 Wind farm Prof. Dr. ir. Harry van den Kroonenburg.

expanding. One maintenance firm started as a result of the restructuring of Lagerwey. Major banks and insurance companies are increasing their activities as a result of financing through the Green Funds.

16.4 ECONOMICS

16.4.1 Electricity Prices

Buy-back prices ranged from 12.6 to 16.3 cents / kWh. For a detailed account see last year's *IEA Wind Energy Annual Report* page 9.

16.4.2 Turbine / Project Costs

There are no reliable statistical data available yet for the years 1996 to 1997. Based on 19 of the 73 projects in 1996, the specific investment per kW installed capacity ranged from a high of 2,992 to a low of 1,554 with an average of 2,416 NLG / kW. The specific investment per m^2 swept area ranged from a high of 941 to a low of 550 with an average of 799 NLG / m^2.

Based on 6 of the 21 projects in 1997, the specific investment per kW installed capacity ranged from a high of 2,417 to a low of 1,744 with an average of 2,087 NLG / kW. The specific investment per m^2 swept area ranged from a high of 1,081 to a low of 668 with an average of 854 NLG / m^2. Turbine costs are still around 70% of total project costs.

16.4.3 Invested Capital

Based on the averages given in 16.4.2, the invested capital for 1996 was 114 million NLG and for 1997 it was 93 million NLG.

16.5 MARKET DEVELOPMENT

16.5.1 Market Stimulation Instruments

As a result of the announced possibility of a mandatory share of renewables after the year 2000 in the new Electricity Act (which should come into effect in 1998), the association of distribution companies (EnergieNed) committed itself to supply 3.2% of electricity from renewables in the year 2000. About one third of this amount is expected from wind energy, corresponding to 750 MW of installed capacity.

Table 16.4 Size of Wind Turbines Installed in 1997.

NAME OF WIND FARM	MANUFACTURER	HEIGHT	TURBINE	DIAMETER	CAPACITY	SWEPT AREA
WP Harry van den Kroonenberg	WindMaster	48	18	43	13.500	26.140
Windpark Waardpolder	NedWind	31	19	31	4.750	14.341
WP Irene Vorrink (2)	Nordtank	50	9	43	5.400	13.070
Vlissingen buitenhaven	Vestas	36	7	29	1.575	4.624
Jacoba-Haven	Vestas	30	7	27	1.575	4.008
Windpark Haringvliet B.V.	Bonus	41	6	44	3.600	9.123
Windpark Beabuorren B.V.	Bonus	40	5	44	3.000	7.603
Windpark Noorderpolder B.V.	Nordtank	50	5	43	3.000	7.261
Windpark Terneuzen B.V.	Vestas	53	2	44	1.200	3.041
Various solitary turbines	Danish		12		6.705	17.228

From January 1, 1998 a system of green labeling is in effect. A producer of wind electricity from now on gets a fixed price plus one Green Labels for every 10,000 kWh. These labels can be freely traded. Price will be formed on a 'stock exchange' where contracts for green electricity can be bought and sold to the highest bidder. Bidders will be the utilities, but also intermediaries, that have to meet their obligation in 'green' electricity. Expected value of a green labeled kWh is NLG 0.05 to 0.06. (Information available at http://www.groenlabel.ned.nl)

A market incentive introduced January 1, 1997 was the Energy Investment Deduction scheme, a provision of the Ministry of Finance. It allows profit making companies to deduct 40% of the investment in wind turbine installations from company profits in the year of investment. The company tax is 35%, so this implies a 14% reduction on invested capital.

From January 1996, under the Accelerated Depreciation on Environmental Investment scheme, a provision of the Ministry of Finance, companies are allowed to freely amortize investments in wind turbine installations, e.g. profit making companies can write off the investment in a wind farm in the first fiscal year. This accelerated depreciation keeps taxable income down so that companies pay less income or corporation tax in the early years. This deferral of tax payments is of benefit to companies' cash and interest position.

In January 1995 the green investment scheme became operational. So-called Green Funds are operated by major banks and recognized by the Ministry of Finance. Green Funds have to invest in green projects like wind turbine installations. Capital is supplied by private citizens and the dividend or interest is exempted from income tax. This allows green funds to offer a lower interest rate on capital of about 1.5 to 2 percent points in 1997. The capital collected from private investors increased to 2 billion NLG in 1997. For them, the interest rates are approximately 4%.

From January 1996 the Regulatory Energy Tax, a kind of CO_2 tax, for small consumers came into effect. The tax applies to electricity, natural gas, medium heavy oil, gas oil and liquid petroleum gas (LPG). Renewables are exempted from this carbon tax. Also exempted are transport fuels. For electricity the CO_2 tax is NLG 0.03 per kWh (excl. VAT) in 1996, 1997 and 1998 for a maximum consumption of 50,000 kWh/year, the first 800 kWh are not being taxed.

The energy tax is paid to the utilities, who in turn pay to the taxation authority (Ministry of Finance). However, utilities are exempted from payment for energy generated from renewables. Instead, they have to pay NLG 0.03 per kWh to the generators of renewable energy; e.g. wind turbines, hydro, solar PV, or biomass.

Various distribution utilities started to offer green pricing. They offer their customers green-, or nature-, or eco-electricity. Customers can, voluntarily, buy all or a share of their annual electricity at 5 to 8 cents higher than normal price (CO_2 tax is included in this price).

With all the incentives in place and the conception of financial models by the financial engineers, bankers, developers and utilities now tell us that money is not the problem.

16.5.2 Financing

Through the Green Funds there is an abundance of capital available. Green Funds of the 3 major banks are competing to invest in wind energy projects with low interest rates. The green interest in 1997 was 3.8 to 5.2% depending on the term of the loan 2, 5 or 10 years. Average interest

Table 16.5 Electricity Production, Windex, Avoided Fuel and Emissions.

WIND ENERGY	ELECTRICITY		AVOIDED FUEL		AVOIDED EMISSIONS		
Year End December 31	Total [GWh]	Windex [%]	Primary [PJ]	CH_4 [Mm3]	CO_2 [kton]	NO_X [ton]	SO_2 [ton]
1986	7		0.1	2	4	7	1
1987	16		0.1	5	10	15	3
1988	26	100	0.2	7	16	24	5
1989	26	83	0.2	7	16	24	5
1990	55	98	0.5	16	34	52	10
1991	72	80	0.6	20	44	68	13
1992	145	93	1.3	41	88	136	26
1993	165	87	1.5	46	99	155	30
1994	251	94	2.2	69	149	236	45
1995	317	88	2.8	87	187	298	57
1996	430	68	3.7	118	252	404	77
1997	451	68	3.9	123	262	424	81

rates on the regular capital market in 1997 were 6 to 7%. All non-utility investors in wind energy finance their projects through the Green Funds. Utilities finance their investments from their own cash flow and calculate with an internal rate of return of 5%.

16.5.3 Planning and Grid Issues

Installed capacity has dropped dramatically in 1996 and 1997. There are 2 main reasons for that: (1) the change from an investment subsidy scheme to fiscal incentives has created uncertainty in the market and (2) development of sufficient sites with building permits in place is increasingly difficult. At least 25 MW were delayed to 1998 because of pending court cases about building permits that were opposed.

To address the problem of the availability of sites Novem has supported a number of studies to approach owners of large real estate and stimulate the multi-functional use of sites. These owners include, for example, the Army, Waterstate, Rijksdomeinen and the National Railway Company.

The technical potential for wind energy on railway grounds (no blades above the railway!) is 750 MW at sites with 5 m/s at 30 m height, of which there is 100 MW at 6 m/s at 30 m. The Railway Company is interested in developing some of the potential.

On October 1, 1997 year Novem started a national campaign ‘Space for Wind Energy’. It is aimed primarily at local decision makers and the local public. The backbone of the campaign is a series of products and services that can be used to assist local authorities to create room and space for wind energy, e.g.:

A so called ‘quick scan’ offered to local communities in order to get a quick estimate of their local wind energy potential; A detailed guideline for planning officials is available, to help them incorporate wind energy in their physical planning schemes;

Excursions to wind farm sites with locals; Support to organize local meetings.

The evaluation of the Administrative Agreement on Location Problems Wind Energy showed that the agreement as such is a useful instrument to improve the implementation of wind energy. Considered as a shortcoming was the fact that it did not contain any sanctions for those parties that did not reach the targets. Also the number of parties involved was judged as being too limited.

16.5.4 Institutional Factors

The 12 (influential) provincial Environment Foundations and the (powerful) Foundation Nature and Environment published a common view and position on the role of wind energy in the Netherlands. This is a major breakthrough. Their view is positive and proactive. They support the development of wind energy in close relation to the ambition of a sustainable energy supply, of which a policy that is truly directed towards energy conservation is a crucial part. They support the 1000 MW target for wind energy in 2000. They will work out guidelines for the selection of locations of wind farms, taking into account the possible damage to landscape and birds. They promise to actively contribute towards the ecological and economical sound implementation of wind energy.

16.5.5 Impact of Wind Turbines on the Environment

The national research program on the impact of wind turbines on birds was completed. The main goal of the program was to collect data on nocturnal flight altitudes of birds in tidal and semi offshore areas. The results of the studies show that the concentrated nocturnal movements of waders between tidal flats and inland high tide roosts are, in general, at present-day wind turbine heights. Waders flying between tidal flats and inland roosts may therefore run the risk of colliding with wind turbines in tidal areas during darkness. However, because waders do not always use the same inland high tide roosts during darkness and during the day, the local situation at night should be taken into account before actual locations for turbines are assigned in tidal areas.

16.6 GOVERNMENT-SPONSORED R,D&D PROGRAMS

16.6.1 Funding Levels

As a result of the R,D&D policy laid out in the action plan *Renewable Energy on the March*, the Novem budget for the wind energy program (TWIN) was raised from 9 million NLG in 1996 to 14.1 million NLG for the years 1997 to 2000. Staff increased from 4 to 6 people.

As of January 1998, Dr. Gijs van Kuik will be the new professor in wind energy at Delft Technical University.

16.6.2 Priorities

The Netherlands R&D-plan *Wind Energy* has been revised for the period 1997-2001. The priorities for R&D subjects were set in an April 1997 workshop attended by the wind turbine and blade manufacturers, the engineering firms and the program managers ECN, TU-Delft and Novem. The plan will be the basis for the research programs for ECN, TU Delft and Novem. The first ten priorities are: development of design codes; expand, adapt and validate engineering rules; development of new rotor concepts; development of a dynamic model of offshore wind turbines; maintaining testing facilities; transfer of knowledge to industry; development of knowledge of 3-D stalled airfoil characteristics; testing of blades and conducting conceptual design studies.

Some specific results from the last few years R&D are computer codes such as: SWIFT which generates a simulated wind field for input in aeroelastic codes; TIDIS,

an aerodynamic correction method for 3D-effects; BLADOPT, an optimization tool for blade design; and SILANT, a tool for comparative calculations on noise emission from blades depending on airfoils used.

16.6.3 New Concepts

There were no major new developments in turbine design that will reduce costs and or improve the technology.

16.6.4 MW-rated Turbines

The 4 x 1MW wind farm Moerdijk, operated by the private investor Windfarmers V.O.F. consists of turbines from NedWind with hub height 70 and rotor diameter 55 m. Electricity production in 1997 was 5.83 GWh for 9,503 m^2 swept area, giving a specific production of 614 kWh / m^2.

Taking into account that 1997 was a bad wind year with a windex of 68%, in a normal wind year this would be 8.47 GWh. This is well above the estimated production of 6.8 GWh annually.

In 1997 another 19 of these machines were to be built. Granting a building permit for this project proved to be extremely difficult. Appeals against it ran to the highest court (Raad van State) with the Ministry of Agriculture opposing the permit. The appeal was rejected and it is expected that the turbines will be on line in the third quarter of 1998.

16.6.5 Offshore Developments

Maximum wind capacity on land based sites is estimated to be around 1,500 MW in 2005 to 2010. The national goal is

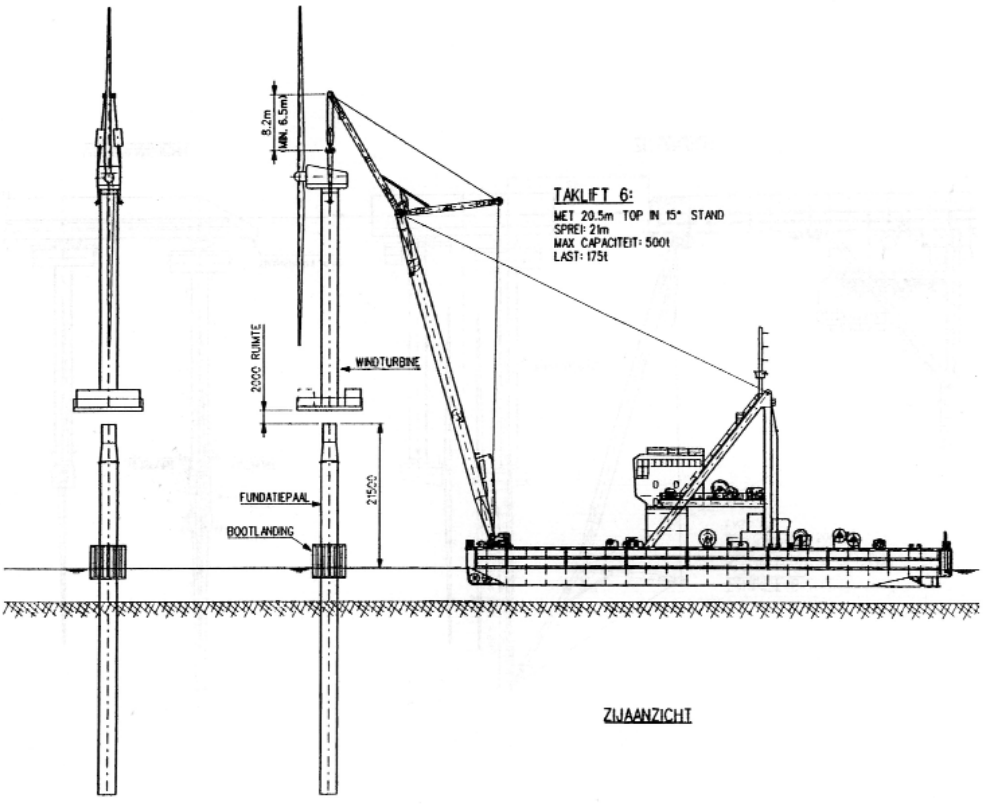

Figure 16.5 Installation sequence wind turbine in near shore wind farm.

3,000 MW in 2020. It is believed that this can be realized with offshore installations.

Novem has carried out a feasibility study of a demonstration project of a near shore wind farm. The wind farm is meant to gain experience and knowledge of offshore installation, construction and operation. The characteristics of this demonstration project are:

Minimum distance to coast is 8 kilometer;
Water depth will be between 5 and 20 m;
One hundred wind turbines with capacity of 1 MW;
Monopole foundation rammed in sea-bed;
Investment around NLG 450 million;
Construction in less than a year;
Employment of 1000 man year during construction and 10 man year for operation and maintenance;
Net energy production 300 GWh per year;
Selling price electricity NLG 0.14 per kWh;.
Exploitation costs NLG 11.2 million per year;
Green interest rate 4.5%;
Term of loan 20 years;
Economic lifetime 20 years;
Guarantee costs project financing 1.5%;
Equity 15/85.

Participants in the study were: the national nature and environment association, project developers, banks, offshore and construction companies.

Representatives from the ministries of economic affairs, the environment and water state were in the advisory council overseeing the study. The conclusion is that this project is feasible under the condition that it be granted a subsidy from the CO^2 abatement fund. It was recommendation to carry out the project. The final report was presented to the Minister of Economic Affairs in November 1997. The minister has said the project qualifies for assistance under the government CO^2-reduction program and that 60 million NLG will be reserved for an offshore project. Preparations are under way to start the next stage.

16.6.6 International Collaboration

For a detailed list of projects see the *1996 IEA Wind Energy Annual Report*.